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FORD FOUNDATION COMPUTER GRANT TO MICHIGAN

The Ford Foundation has made a grant of $900,000 to the University of Michigan to finance a three-year study on ways of using computers to upgrade engineering education. The study will be conducted by the engineering faculty of Michigan, supplemented by visiting professors from other schools. Results of the study will be made available to other schools through periodic reports to be issued by the project and through summer workshops in 1960 and 1961. Under the project many of the regular courses of all departments of the College of Engineering will be experimentally modified to see whether advantage can be taken of the availability of powerful computational facilities for teaching material previously not included or not treated adequately. The project is directed solely at the use of computers as tools for engineers and not at the design of computers. It will include study of both analog and digital computers of both small size and large size. It is anticipated that the study will demonstrate that it is both practical and desirable for all engineers to be trained in the use of computers.

1960 ANNUAL MEETING, PURDUE, JUNE 20–24

Do you Know

► That this is for your ladies? Take it home to them. Leisurely morning coffee every day in the Union Building; daily historical and campus tours; tea with Mrs. F. L. Hovde, wife of Purdue's President; What's New in Foods and Nutrition; tour of Eli Lilly Plant; tour of National Homes plant; a splendid tea and shopping at Market Square; readings from Hoosier poet, James Whitcomb Riley; all-day trip to Turkey Run State Park; Flowers for the Home and Personal Adornment; and freedom from the kids because they have their own programs. Yes, that is the Annual Meeting for the ladies. Why not take them to Purdue, June 20–24?

► That this is for your kids? Ages 3 and 4 spend the entire day at the Purdue Nursery School. Kindergarten children spend mornings at the Co-Recreational Gym and eat lunch and spend the afternoons at the Purdue Nursery School. Grade schoolers have headquarters in the Co-Rec Gym. There will be swimming; story and records; ice cream social; magic show; trip to Happy Hollow Park; movies; puppet show; talent contest; family trip to Turkey Run; trip to creamery; TV demonstration; arts; crafts; and games. The teen-agers also will be headquartered at the Co-Rec Gym, and there will be swimming; golf; tennis; mixer; picnic; sock hop; tour of speech-hearing clinic; trip to model shopping center; readings from the Hoosier poet, James Whitcomb Riley; all day trip to Turkey Run; movies; bowling; billiards. So why not take the kids to Purdue, along with your wife; they will be busy, well supervised, and glad to have you out of their way.

► That each of you working in industry during the coming summer has an ASEE mission to perform? Every effort made by ASEE during the past few years to interest industry in its activities results in the general statement, "Why didn't we know about you and your work a long time ago?" This means that ASEE as an organization and its members as individuals have failed to adequately inform those in industry of the work of ASEE and its objectives. Consequently the request is made that each of you working in industry this summer or having other direct contacts with industry by virtue of research, consulting, or placement activities should make a point of informing people in industry of ASEE and its work. Brochures for industrial and individual memberships have been sent to all deans of engineering and on each campus there is a YET Chairman who can provide the material. If neither source is fruitful, write to the Secretary of the Society.

► That companies should be encouraged to advertise in the JOURNAL OF ENGINEERING EDUCATION? ASEE as an organization is making a concerted effort to increase the amount of advertising and considerable success has been encountered during the past year. The amount of advertising by industries, however, is still low, and each of you having an appropriate contact should encourage industry to advertise in the JOURNAL. If each of you does his part the total effort will be a real contribution to the growth and development of the Society. Do your bit!

► That an interim study of Engineering Enrollment and Faculty Requirements has been made by CDEF? Though undergraduate enrollments declined by 7% for the three-year period, 1956 to 1959, graduate enrollment increased by 44.4% and total enrollment declined 2.9%. Because such a large portion of freshman subjects are not taught by engineering faculties it was believed that the most significant comparison could be obtained from an examination of the junior-senior and graduate enrollments, which indicated an increase of 12.5% for the three-year period. For the same period there was a 14.7% increase in engineering faculties. The actual increase

is 1,331. In addition there were 828 replacements. Consequently in the three-year period new hirings amounted to 2,159 engineering teachers. The actual shortage indicated in 1956 was 732 budgeted openings or about 8% of the number of engineering teachers in 1956. In 1959 the number of unfilled budgeted openings is 656 or 6.3% of the 1959 number of engineering teachers.

► That the University of Baghdad is in need of staff in almost all branches of engineering and related subject matter for the year 1960–61? Anyone interested should write directly to Mr. Salih J. Al-Toma, Cultural Attaché, Embassy of the Republic of Iraq, 2400 Sixteenth Street, N.W., Washington 9, D. C.

► That a "Metals Documentation Service," automated literature searching, has been established by the American Society of Metals? The purpose is to provide the metals industry with immediate information on metals and metals engineering appearing in current world literature. A photocopy service is included, which is based upon the "fair use" interpretation of the copyright law, i.e., ASM merely provides single photocopies of articles in various journals at cost. ASEE is cooperating.

► That 76 of the 580 Summer Fellowships for Graduate Teaching Assistants of NSF went to engineers? There was a total of 1,362 applicants. Forty colleges of engineering are participating in the program. Wisconsin leads with six; Columbia, Cornell, and Purdue follow with four each; and Michigan State, California at Berkeley, Houston, and Texas come next with three each. MIT got one.

► That there were 268 engineers among the 1,190 recipients of the National Science Foundation Cooperative Graduate Fellowships? A total of 3,091 applied. Sixty-five different colleges of engineering participate in the program, 25 fellowships going to MIT, 14 to Purdue, 12 to Michigan, 11 each to Illinois and Stanford, and 10 to Iowa State. No other college of engineering was to be attended by more than 8 recipients.

► That NSF published "Programs for Education in the Sciences," which also includes engineering? The six graduate fellowship programs for engineers are described, along with the summer institute and summer conference programs. Engineering teachers also will be interested in the information on teacher improvement programs, international science education programs, and course content improvement programs. Engineering teachers and graduate students should be familiar with these programs. See your dean—he got a copy from ASEE even if he didn't get one from NSF!

► That NSF still is disappointed in the response of engineers to its programs? Do we have too little imagination and initiative, too much inertia and complaisance, or do we think we are too busy with research and consulting to pay much attention to the many programs which NSF sponsors?

► That NSF sponsored a Conference on Mechanical Engineering Laboratory Teaching? There was a general belief that good laboratory teaching is much more difficult than teaching in a quizz class and that experienced instructors worked very hard to get out of teaching laboratory courses. This situation is more or less chronic and not limited to mechanical engineering. The sad situation probably is influenced by the fact that laboratory instruction is expensive, even when the cheapest staff is used. The general failure of getting all teachers into the laboratory and correlating laboratory with class room work was cited as a primary reason for the stagnation of laboratory courses. A few schools are rectifying this situaiton, but a lot more needs to be done if efforts to improve engineering education are sincere.

► That a general Conference on Civil Engineering Education will be held at the University of Michigan on July 6–8? This conference for 150 is the result of two planning conferences sponsored by Cooper Union and having the co-sponsorship of ASEE and ASCE, with financing by NSF. Attendance will be by invita-

tion. The general Chairman is Professor F. A. Wallace of Cooper Union.

► That the problem of the complexities and confusion in national and international systems of units was discussed by Section M, Engineering, of AAAS at Annual Meetings in both 1958 and 1959? As a result of the policies and opinions expressed in the 50 papers presented, Section M has now contacted EJC and invited them to enter a joint venture to develop a method of spreading the existing information about the problem and to organize a program of intensive study in the various specialties of engineering to determine some specific steps toward the resolution of the problem. It is interesting to note that the metric system has been adopted in the pharmaceutical industry and that there is an increased use of decimalization in the motor industry.

►That the International Conference on Electrical Engineering planned for July at Syracuse University is postponed to the summer of 1961? Delays in obtaining financial support is the reason.

► That there was a mistake in the March "Do You Know?" The three reports listed on page 519 and recommended to engineering educators for reading in related fields are not available at no cost from the Institute of Higher Education at Columbia University. "The Liberal Arts as Viewed by Faculty Members in Professional Schools" and "Liberal Education in the Professions" are available from the Teachers College Bureau of Publications, 525 West 120th Street, New York 27, New York and are $1.50 each. "Are Liberal Arts Colleges Becoming Professional Schools?" is available from the same organization for 50¢ each. Most sincere apologies are extended to all concerned for this error.

► That the Bureau of Labor Statistics is studying long-range demand for engineering and scientific personnel? The study is being sponsored by the National Science Foundation and has as its purpose the development of techniques for providing reasonably accurate long-range projections needed by industry, government, educators, and others concerned with establishing policies on recruitment, training, salaries, etc. A particularly detailed study will be made of the chemical and electrical equipment areas. The study will be based on existing trend data available in the BLS files and on interviews.

► That some interesting analogies are being developed to distinguish the engineer from the scientist? An interesting one is that of F. T. Mavis. "Certainly engineering and science are as essential one to the other in advancing our civilization and general well being as a hen and rooster are one to the other in maintaining the flocks that keep us supplied with fresh eggs. The engineering hens round out the eggs, hatch them, and start the brood scratching and foraging for themselves. The scientific roosters contribute some fertile ideas in the cycle and do most of the crowing." Another heard more often and without identification of the originator is "Why build a bridge if you know how?" A third is that if a satellite orbits it is a scientific achievement, if it doesn't it is an engineering failure.

► That the increased recognition accorded to the scientist has had some unfortunate side effects, including a decline in the public mind of the importance of the engineer? Because of the loose usage of the term *scientist* in connection with space vehicles, the public image of the man responsible for space vehicles is that of a physicist or chemist rather than that of an engineer. The acclaim accorded to Soviet scientists on the basis of the demonstrated large payload capacity of Soviet rocket engine boosters is another indication of a tendency to attribute to science what is largely the result of technology. No one will deny the contribution of physicists or chemists to space propulsion and space vehicles, but the role of the engineer is the central one and this fact is often lost sight of. The importance of engineering science and engineering are certainly not diminished by the steadily increasing output of sci-

ence and the speed with which this output can be put to practical use. The richer supply of raw material in the form of basic knowledge is making the job of the engineer ever more demanding, ever more interesting, and ever more important. These statements were made by a physicist, Dr. A. H. Flax, Chief Scientist of the U. S. Air Force at the Awards Dinner of the Institute of Aeronautical Sciences' 1960 Northeastern Student Conference at Polytechnic Institute of Brooklyn.

► That *The Characteristics of Engineers and Scientists* is a book just published by the University of Michigan Bureau of Industrial Relations? The findings and recommendations are based on interviews with executives, supervisors, and non-supervisory professionals in 10 well-managed firms with extensive research organizations. Judging from a news release about the book, there is a rapidly growing new breed of scientists and engineers in American industry. They are college educated and money-minded, often unlike their bosses in training and motivation. They are intensely interested in their work, but they do not always regard the job well done as its own reward. They are interested in personal-advancement and recognition and do not respond well to many traditional management practices. They—and their bosses—regard them as a breed apart in the business organization. L. E. Danielson of the University of Michigan School of Business Administration is the author.

► That the space-age engineer must have a distinct capacity for innovation? He will have to work closely with scientists of entirely different and diverse fields. And to do this he will have to understand what they do, and of course communicate accurately with them. A B.S. or M.S. of 20 years ago, or even 10 years ago, is no assurance of an understanding of today's technology. A space-age engineer with a nuclear-age education is out of step with the times. We must increase the numbers of students in engineering as well as intensify the educational process to which they are exposed. These are some of the statements made by J. M. Gavin, Executive Vice President of Arthur D. Little, Inc., in *Mechanical Engineering* for March 1960.

► That there is a real need for scientists and engineers to run for public office? In the words of Joseph Kaplan, physicist of the University of California, "Practically every major problem facing the country today, from national defense to smog, demands a basic understanding of science." Dr. E. I. Rabinowitch, botanist at the University of Illinois, has made a similar statement. In the past the major decisions on the part of state and federal governments have related to matters of law, etc., and lawyers were "naturals." The situation now has changed! This also means the engineers and scientists must accept a real responsibility for adequate communication with the layman.

► That ASEE's Industrial Fellowship program permits the contributions of small amounts by individuals and industries? The small amounts will be held until the total reaches an amount appropriate for a fellowship. All such contributions should be sent directly to the office of the Secretary with a statement that it is for the Industrial Fellowship fund.

► That the number of ballots cast for the election of officers increased almost 90% over last year? The total of 533 is still small, but is becoming respectable. A few comments always are received about having only one name on the ballot for each office, but it is highly desirable that there not be a large contingent of leaders in engineering education going around with the stigma of rejection by their peers on their records. It is better to have "never been called" than to "have been found wanting."

► That you want to be sure to attend the Annual Meeting at Purdue? If you aren't going, give your program to a friend and urge him to go. You don't have to be a member to attend.

W. Leighton Collins
Secretary, ASEE

Do Computers Belong in the Engineering Curricula

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Introduction

The concept of "electronic brain," which has been before the public for several years, has given the layman an image of a fantastic, complex monster with a maze of twinkling lights. In addition, such descriptive names as MANIAC, GENIAC, and IDIOT, coined by developers of these machines, further serve to enhance the mystery surrounding modern computers. Through the medium of television, the American public has been treated to the spectacle of watching computers perform analyses of election returns as well as such tasks as selecting suitable marital prospects for show contestants—to prove that while people are funny, applications of modern computers can be even funnier. In spite of the frivolous impression of machines made in the performing arts, they have nevertheless had a profound effect upon modern science, engineering, and industry.

Computers have been allied with the rapid technological changes that have taken place within the last twenty years. Developments in such fields as electronics, atomic and nuclear physics, chemistry, and astronautics have taken place so rapidly that they have increased the requirements for complex analytical work in engineering and science, and accelerated efforts to introduce the developments in basic fields to industrial and commercial products as well as for purely military applications. This in turn has brought about a serious revaluation of the efficiency of the engineering design technique of "cut and try" procedures in development work.

But how often has an analysis of a system that we wanted to design, led to mathematical formulations that either could not be solved by available techniques, or if they could be solved, would require months of arduous work. The comment would usually be, "Well, this is all very nice, but let's go ahead and build it and then see what happens!" Today, however, digital and analog computers provide the means for the engineer and scientist to investigate and analyze the most complex systems with which he is confronted in his daily work.

Although the history of computers goes back several thousands of years, the analog and digital computers as we know them today are of relatively recent vintage. The general purpose electronic analog computer, which was brought about by the development of the operational amplifier, was an infant in the 1940's. In digital computers, magnetic tapes and drums for storing programs and large quantities of data were also just blossoming forth at the end of the '40's. In a period of little more than 10 years, we find that modern computers have assumed an important role in industry and science. They have become standard equipment in the research, development, and manufacturing departments of many companies and laboratories. The growing number of concerns manufacturing both analog and digital computers—whose equipment range from small desk type computers to the giants filling huge laboratories—is additional evidence of the trend toward increased computer utilization.

Engineering College Courses on Computers

College catalogs of 132 schools having ECPD accredited engineering courses were reviewed to establish both the number of courses presented on the subject of computer application as well as to obtain some idea of the nature of the

TABLE 1

SURVEY OF COURSES ON "COMPUTER APPLICATIONS" OFFERED IN AMERICAN UNIVERSITIES

	Undergraduate Courses			Graduate Courses		
	Digital Computer	Analog Computer	Combined Dig. & Analog	Digital Computer	Analog Computer	Combined Dig. & Analog
I. Universities Offering Courses						
Electrical Eng. Dept.	19	20	17	17	18	16
Mathematics Dept.	12	3	3	5	—	2
Other Depts.	—	2	3	2	1	2
II. Courses Including Computer Laboratories	10	11	6	3	3	3
III. Total Number of Courses Offered						
Electrical Eng. Dept.	22	25	19	26	20	21
Mathematics Dept.	20	3	4	6	—	4
Other Depts.	—	6	4	2	1	3

material presented in these courses. The results of the survey have been summarized in the Table 1.

Since modern analog and digital computers are electronic devices, many courses are offered in the design and construction of computers. These were not included in the survey inasmuch as we were only concerned with courses which had the primary objective of enabling the engineer or scientist to utilize the computer in his work—as a tool for computation and analysis.

In general, it is interesting to note that the majority of courses are conducted by the electrical engineering departments of the universities. Here, on both the undergraduate and graduate levels, we find an almost equal division of courses offered on digital and analog computing. The only other department offering any number of courses in the field of computer applications is the mathematics department. Here, practically all of the courses offered are in the field of digital computing. In certain courses, the analog or digital computer is introduced as a part of a course where its application is particularly useful (e.g., servo design, vibrations, etc.). Some universities offer only one or two courses on the application of computers, while others list as many as ten courses on the subject. Over 20 of the universities indicate that appropriate laboratories—digital and/or analog—are available for use in conjunction with the lecture courses.

With over half of the accredited engineering schools offering courses in the field of computer applications, it is apparent that computers have had a definite effect upon the curricula of the professional engineering program. But it is interesting to investigate two questions which are brought to light; why is the subject of computer applications taught primarily by the electrical engineering department; and, what is the nature of the courses offered?

Departmental Responsibility for Computer Education

As mentioned previously, analog and digital computers are basically electronic devices—and hence require someone familiar with electronic circuits to keep them in proper operating condition. Thus, they are physically located in the electrical engineering department. In addition, there are courses offered by the electrical engineering departments in the design and development of circuitry and components for modern computers. In certain instances, electrical engineering departments have either designed or built computers for their own work, or

developed computer components as part of research and development projects.

Since World War II, the analog computer has played a prominent role in the development of servo mechanisms and feedback control systems. This field is in the province of electrical engineering, and it is therefore necessary that the electrical engineer be acquainted with the analog computers as a tool to aid him in the design of control systems.

Until recently, the electrical engineering curriculum was the only engineering program with a serious concentration on mathematics. Differential equations have been a required course in electrical engineering for many years, while in other engineering curricula, differential equations were either an optional or elective course. Such advanced mathematical physics topics as operational techniques in calculus, vector analysis, and functions of a complex variable are also of considerable importance in electrical engineering. This can be attributed to the fact that the electronics engineer is usually concerned with dynamic systems involving high frequencies. However, in other fields of engineering—mechanical, chemical and civil—analysis of systems has generally tended to ignore dynamic effects, since the frequencies in the systems were usually quite low. Since the electrical engineer has been concerned with dynamic systems and their resultant differential equations, it is obvious that he would be interested in using computers to assist him in their solution.

Fortunately, the present trend in all engineering curricula is to include more courses on dynamic systems and their analysis. As an indication of this we find an increasing number of courses on dynamics of machinery, vibration, shock and impact phenomena, etc., as well as the mathematics required to complement these courses. In many of these courses analog or digital computers are used as an aid in the design work and have been included either as part of the lecture or as a laboratory experiment.

The Nature of Available Courses

Courses in digital computer applications presented during 1959–60 range from a general course to familiarize the student with the concepts of analog and digital computation, to courses which detail methods in the set up and programming of a specific large-scale computer. In the latter, such topics: as computer coding for high-speed automatic computers, with consideration for a single address system; machine operation; loops; set up routines, and other standard procedures are presented. The general courses, however, are usually devoted to numerical methods of analysis and their use in solution of simultaneous linear equations, algebraic and transcendental equations, problems of interpolation, numerical integration and differentiation, numerical solution of differential equations, finite differences, techniques, linear analysis, etc. The objective of such courses is the utilization of these techniques to solve problems by means of a digital computer.

Unfortunately, the majority of digital computer courses offered on the applications of computers in engineering concentrated on the detailed techniques of programming problems for the digital computer. Very often such courses were directed towards a specific computer and the interpretive codes as well as basic machine language used for programming that computer.

Although many of the titles of the analog computer courses indicate that they are concerned with the application of computers, many course outlines in the catalogs reveal that the effort is concentrated on familiarizing the student with computer circuitry. As a result, only a minimum of time would be available to provide the student with basic concepts of analog computing and to indicate where and how the computer would be most effective in the solution of engineering problems.

It would appear that the one-semester combined analog-digital course has the most to offer the student on the subject of computer applications. In such courses the basic principles of each type of computer are outlined and then a series of specific examples of computer applications to engineering problems is presented. With this type of background,

the engineering graduate can determine—when the need arises—which type of computer would be of value to him in analyzing his particular problem. At this point he can either learn how to use the computer required for this job, or to formulate the mathematics of the system in an appropriate form to have it solved on the computer, and then bring the problem to the digital or analog computer laboratory and have program specialists take it from there. Here we come to the question of the advantages and disadvantages of the "closed" and "open shop" type of computer laboratories. Since there is something to be said both for and against each of these methods and the debate is presently in high gear, it is best to leave the subject for discussion at some other time.

Are We Heading in the Right Direction

On the basis of the survey there are two conclusions that we can come to: 1) The universities have done a good job of introducing the subject of computers and computing techniques into the curricula. Although computers are relatively new in the field of engineering, apparently many good courses have been developed and several texts are available today on the subject of both analog and digital computing. 2) Since computers are basically electronic devices, their instruction is usually carried out in the department of electrical engineering. This results in an inclination toward the subject of computer components and circuitry. Many courses are offered—specifically in the field of digital computers—which are directed more towards operation and programming techniques for large scale computers than towards general information as to the type of problems which can be solved on the computers and the method of formulating engineering problems for solution on these computers.

The need today in engineering is for a greater capability and ability in the mathematical formulation of engineering problems. It is apparent that the engineer is increasingly required to translate a physical problem, by means of the basic laws of nature, into mathematical terminology. It is more important than ever before to emphasize the fact that mathematics is the handmaiden of science and engineering. It is the task of university training to stress such concepts as the analogies of nature, to give the student an understanding of the similarity between the laws which apply in the various physical systems, and to then provide a thorough background to work with these systems. Although electrical, mechanical, civil and the chemical engineers each deal with different forms of hardware, they should realize that the basic laws and resultant equations formulated from these laws are often of the same form. They should also understand the equations they produce to be able to determine from the equations themselves some of the fundamental characteristics of the system which these equations describe. Such properties as time constants, natural frequencies, boundary conditions, stable or unstable solutions, and other factors can be inferred from a simple analysis of the equations even before they are solved. Familiarity with numerical techniques for solving problems should also be developed, not only for their intrinsic value, but also for the intuitive feeling they develop for understanding the concepts of the derivative, integral, etc.

The four years allowed for college education are too short to permit time for the detailed study of hardware—which is what a specific computer, analog or digital, really is. It is the responsibility of the university to teach the modern engineering student more of the fundamentals of his field, and to present the scientific laws and mathematics required to enable the engineer to use the modern tools available to him for the practical solution of engineering problems.

The Faculty and the Computer—Some Problems and Goals

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What is the proper relationship of the faculty of an engineering school to the computer? This question is approached by proposing a set of idealized goals and discussing some of the typical problems and pitfalls which are commonly encountered. The objective of the paper is to state the problem of proper relationship in a broad sense rather than to suggest solutions to isolated parts of the problem.

The Computing Faculty

The fundamental thesis of this paper is that the faculty-computer relationship must embrace the entire faculty—that the ideal "computing faculty" includes the entire faculty of the engineering school. The development of a basic philosophy and attitude toward the computer and a spectrum of computer know-how which involves the total faculty is proposed as a fundamental goal.

An impression that is frequently encountered is that computers represent an area of narrow specialization of concern only to a small segment of the faculty. The "computer man" concept is an unfortunate product of recent evolution since it implies concentration not only of computer know-how, but also of real appreciation and understanding of the implications of computers, in the hands of a very few individuals. Certainly there is an important role to be played by the computer specialist on the engineering school faculty. However, computers will not achieve a natural place in engineering education until the faculty as a whole is related to computers in a meaningful way.

Ironically, the lead in broadening the base of computer know-how is being taken largely by the students rather than by the faculty. The future engineering student probably will learn to communicate with computers at the freshman or sophomore year and will expect a meaningful relationship to the computer throughout his educational program. The challenge to the faculty is obvious.

A Basic Relationship

What constitutes the basic relationship which each individual faculty member should bear to the computer? The following may be stated as ideal objectives for the minimum relationship:

1. A mature perspective and philosophical attitude toward the computer as a means for extending the mental and intellectual capabilities of the human being.
2. An appreciation of the implications of the computer in "an intellectual revolution in thinking," to quote Gordon Brown, and in "the human use of human beings," to quote Norbert Wiener.
3. A basic knowledge of the functional characteristics and technical capabilities of the computer in terms meaningful to the individual.
4. A basic understanding of how man communicates with computers and of the significance of programming.

The first two objectives are related to the basic attitudes of the faculty member toward computers and the second two are related to a minimum knowledge

about computers. Such a basic relationship does not require that each and every faculty member be in direct contact with a computer nor be skilled in the use of computers. However, it does imply that no faculty member can properly adopt an agnostic relationship toward computers.

Computer Philosophy

The attitude of the faculty toward computers is an important part of the basic relationship which has been proposed. What constitutes a mature perspective toward computers? One of the basic objectives of the engineer is to extend the capability and capacity of human beings to fulfill their needs and desires. The extension of man's ability is normally accomplished by some form of machine, in a broadly defined sense. The extension of man's physical capabilities by machines which generate and utilize energy has occupied the major attention of engineers during the era of the industrial revolution. We may now be said to be entering an era of *intellectual* revolution based on the use of machines which process information. Such machines extend by constantly increasing orders of magnitude the mental capability and capacity of the human being to handle information. Both the power machine and the information machine offer the possibility of relieving human beings of the burden of routine tasks. In this sense they can be effectively used to replace human beings in the interest of the human being. However, one does not fully exploit the machine by a mere one to one substitution. Clearly, power machines are not limited to a duplication of the muscular actions of the human body. The same holds true for information machines—they are not limited to the equivalent of manual methods of solving problems. The exploitation of information machines in fulfilling man's needs in terms of entirely new levels of problem solving capabilities presents a tremendous challenge. The roots of success in meeting this challenge are imbedded in the fundamental attitudes of the coming generations of engineers, attitudes which they will develop as students under the influence of the engineering school faculty.

Extreme Views

Instead of a healthy perspective toward the proper role of computers in engineering, one unfortunately encounters extremes in attitudes toward such devices. Computers are typically labeled as brains, idiots, fast adding machines, slaves, enslavers or glorified desk calculators. One is apt to encounter three rather basic extremes in attitudes toward computers. These include the crusaders, the agnostics and the atheists. The crusaders are, of course, the people who are thoroughly sold on computers and are trying to sell everyone else on their supreme merits. There is nothing wrong with enthusiastic support for computers but there is a danger in carrying this attitude to an extreme, especially when the extreme view has adverse psychological impact on other people. The crusader gives the impression that computers are the sole salvation of mankind and technology and gives the impression of being obsessed by their power. The crusaders can be further classified in terms of those who know what they are talking about, and those who do not know what they are talking about. Unfortunately, many crusaders fall into this latter category.

The agnostics include those who know nothing about computers and are quite proud of the fact. Such people often make a point of avoiding any tinge of computer know-how, justifying their position on the premise that they are above computers. Some agnostics just don't want to be bothered by the whole subject, and others just don't want to be identified with the crusaders.

The atheists include those at the opposite extreme from the crusaders. Such people are often antagonistically opposed to computers and find the crusaders quite obnoxious. The atheists often consider the application of computers to be a communicable disease which distorts the perspective of people. They are convinced that computers have been grossly oversold and have their own kit of propaganda with respect to computers. Such extremes in attitudes constitute real prob-

lems in achieving a basic relationship of the faculty to the computer but are part of the growing pains of any new field and will gradually melt away as the base of mature understanding is broadened.

A Spectrum of Know-how

Having stated a minimum relationship which embraces all members of the engineering school faculty, we turn to the question of specialized knowledge. How should the engineering school approach the question of technical competency with respect to computers? The ideal goal may be stated as the development of a natural spectrum of computer know-how on the part of the entire faculty. This spectrum includes the following elements:

1) *Design*—engineering and design of computer components, circuits, and systems.
2) *Communications*—computer programming langauges and the general problem of man-machine communication.
3) *Mathematics*—the mathematical subjects, methods, and techniques which are related to the effective utilization of computers.
4) *Applications*—the computer as a problem solving tool of modern engineering to be usefully exploited as a new kind of engineering ability.

The faculty should include a core group in each of these areas with a primary interest in computers. However, these are not sharply defined categories and many hybrid combinations are possible. In addition to the core groups, a healthy distribution of computer knowledge calls for much larger groups with secondary interests in these areas. Whereas the core groups should be concerned with advancing the state of the art, the secondary groups are more concerned with using the state of the art in their educational and research activities. The scope of the four basic branches of computer knowledge and the corresponding relationships of the faculty to the computer are more clearly identified in the following remarks.

Design

Those concerned with computer design pose no identification problem due to their direct relationship to the development of computers as physical devices. The computer design group should include some who are interested in such topics as design of pulse circuits, the development of new and improved memory systems, and the over-all logical design of computer systems. This latter group can be broken down into two subgroups: those interested in the design of general purpose computing systems, and those interested in the development of special-purpose computers. Special-purpose machines may take a variety of different forms including computers currently being developed for use in missile and aircraft control systems, computers for controlling machine tools, and computers which will be integrated with chemical process control systems. While the interests of this design group are primarily in the circuitry and logic of the computers, these designers must have contact with those who are going to use the machines, at least to the extent of knowing what the over-all specifications for the various portions of the machine should be.

Communications

The computer languages group includes those faculty members with a high degree of specialization in the general field of computer programming. In the interest of making it easier for humans to communicate with machines and in the interest of more efficient use of machines, the field of computer programming languages has emerged. The faculty in this group is basically interested in languages for describing computation processes, in computing with symbolic expressions, and in the development of compilers and symbolic assembly programs. As such, these people are the experts in computer programming and provide an extremely important link between the user and the hardware. As a result of the basic interest of the computer languages group in the communications problem and due to their deep understanding of machine capabilities, it is not

surprising that such people are taking the lead in the general field of artificial intelligence. The problems and possibilities of making machines behave intelligently cut across many fields but find a focal point in programming, particularly at the experimental research level.

The development of automatic coding systems which permit the engineer to communicate with the computer by alphabetic statements and mathematical symbols has a very important implication in the relationship of the faculty to the computer. From earlier exposures to computers, many faculty members are apt to retain images of computer programming based on machine-language coding and all of the detailed skills associated therewith. Based on such images, many faculty members operate on the premise that computer programming is a task to be handled by skilled technicians, and as such, neither the faculty member nor the student needs to be acquainted with programming. The concept of an engineer-coder-computer relationship is being rapidly replaced by an engineer-language-translator-computer relationship for the majority of engineering users. This means that even the occasional user can easily communicate directly with the machine via a symbolic language statement of his problem instead of via another human being. Such approaches greatly broaden the base of faculty users and make it possible for the individual to exercise his own ingenuity in exploiting the computer as a personal tool.

Mathematical Methods

The faculty group interested in mathematical methods covers a wide spectrum in itself. Such people find their greatest challenge in the development and general utilization of the mathematical methods and techniques which become of both practical and theoretical significance in light of the capabilities of the computer. However, this interest in computing machines and in particular machine applications is of secondary importance. Within this group, one would expect to find faculty members interested in such subjects as numerical analysis, operations research, Monte Carlo methods, game theory, simulation, Markoff processes, linear and dynamic programming, statistical analysis, and similar classical and modern mathematical methods which have emerged as powerful engineering tools with the availability of computers.

It should be made clear that in identifying the mathematics group we are speaking of those professors within the engineering school who are active in developing and enlarging mathematical methods and not of the staff of the mathematics department. Certainly one would expect strength and activity in the mathematics department in such subjects as previously enumerated. However, the suggested goal of a spectrum of computer know-how in the engineering school also requires persons knowledgeable in such subjects on the faculty of the engineering school. Indeed, knowledge of appropriate mathematical methods is an integral part of computer know-how and is fundamental to fully exploiting the use of the computer.

The mathematics group should be widely distributed throughout the engineering school. Ideally, each principal field of engineering should have at least one person especially competent in the mathematics of computer methods to open up new mathematical approaches within his field. Often such a person can effectively bridge the gap between the problems of a field of engineering and the computer. Seldom will the approaches to problems as historically formulated and solved in a particular field of engineering be the approaches most appropriate to computer methods. Usually the problems must be reformulated on a more basic level and quite different problem solving methods must be applied. Modern mathematical methods, which depend on the computer for their operational usefulness, frequently provide the framework for such activity.

Applications

The final and largest group to be identified includes those professors whose primary interest in computers is in their application to the solution of engineer-

ing problems. Such professors are interested in computers as a means to an end —a means of more effectively and efficiently solving engineering problems. The computer is accepted and used as an extension of their mental and problem solving capabilities to the extent that it is applicable. A small core group might very well consider the application of computers to engineering problems as their principal field of interest. Such a group must be well grounded in computer-based mathematics but their primary interest in computer methods stems from their desire to employ computers as an aid in solving engineering problems rather than from an interest in developing computer oriented mathematical techniques.

The average engineering professor interested in computer applications is concerned with computers as a secondary field. His principal interest might lie in design, control, experimental engineering, or a particular branch of technical specialization. Computers may have considerable influence on the subject matter he teaches and on his method of presenting material, but the computer itself remains in the background. The computer is brought into the picture in his academic and research work only when it is appropriate to do so. This implies that the professor has sufficient computer know-how to do this in a natural way. Such professors often find their most extensive contact with the computer itself via thesis students and research activities. However, if the professor is to properly supervise such activities, he himself should obtain a reasonable degree of technical knowledge with respect to computers by first hand experience.

A Spectrum of Courses

If one has a spectrum of faculty knowledge and interest in computers, one should expect to find this reflected in the courses being taught by the faculty. This carry-over has indeed occurred in the Engineering School at M.I.T. where the following course titles represent examples of subjects currently being taught or planned.

Introduction to Automatic Computers
Introduction to Digital Computers
Introduction to Machine Computation
Digital Systems Engineering
Switching Circuits
Finite and Infinite State Machines
Systems Engineering and Operations Research
Computer-Programming Languages and Artificial Intelligence
Methods of Engineering Analysis
Analysis and Design of Engineering Systems
Numerical Methods of Structural Analysis
Computer Approaches to Engineering Problems
Mathematical Methods in Civil Engineering
Digital Computers in Nuclear Engineering
Analytical Treatment of Chemical Engineering Processes

These courses range from the freshman level to the graduate level and are drawn from the offerings of the electrical, mechanical, chemical, aeronautical, civil, and nuclear engineering departments. Each is concerned directly or indirectly with computers in the spectrum which has been outlined. Such courses basically provide an opportunity to couple professors with interests in such fields to the students and are distributed throughout the educational program and organization of the School of Engineering. A distribution of this type allows the computer to find a natural place in the engineering school—and constitutes at least one approach to achieving the goals which have been proposed.

The Computing Facility

Thus far, the computer has been referred to in a very general way. To be more specific, we shall briefly consider the relationship of the faculty to the actual physical device. As a basic goal already largely realized in many engineering schools, the faculty must have direct access to an actual computer to achieve a meaningful relationship. Direct contact with the computer appears to be the most efficient if not the only

way to acquire both technical know-how and a real understanding of the implications of computers.

However, there is more to the accessibility of a computer than mere physical presence. Herein lies one of the basic problems of the computer in an academic institution. Due to the psychological impact of the cost and speed of computers, considerable importance is attached to the operation of a computer at its fullest capacity and at maximum efficiency. Exceptional care is taken to avoid wasting computer time. Such measures of success are essential in a commercial computer installation. However, the computing facility in an academic institution should be quite a different atmosphere. The computer should be considered as an instrument of learning with all the rights and privileges of equipment in an academic laboratory. This is not to imply that academic computing facilities should be operated inefficiently. It does imply that the measure of efficiency should be that associated with any academic laboratory—the extent to which it serves and advances the educational and research programs of the faculty and students.

One of the necessary evils of computing facility operation is the scheduling of time. To efficiently schedule time and still avoid putting the user under pressure represents a basic conflict. The same is true of necessary rules and regulations governing the use of the computer. Obviously, some degree of control over the use of the computer must be exercised. However, scheduling and control should be accomplished with a minimum of psychological and mental obstacle to the academic user. Faculty people historically have placed a high degree of emphasis on freedom of laboratory activity. As such, there is a natural tendency to rebel against any undue restraints in the use of a centralized laboratory facility such as the computer. Each faculty member should rightfully feel that the computer is a direct extension of his own personal laboratory and not a laboratory belonging to some other faculty member or group. Such an attitude toward the computing facility is fundamental to the concept of relating the entire faculty to the computer.

If one attempts to satisfy the entire spectrum of faculty interest in computers by providing one single computing facility, problems arise immediately. Those interested in design desire access to a machine into which they can connect experimental elements, such as new memories, while many of those interested in applications are concerned merely with utilizing standard equipment in a standard fashion to solve their problems. They are interested in availability and reliability rather than extreme flexibility. However, even among the applications group are members who wish to study problems involving unusual input or output requirements that are not easily accommodated by a standard machine. Consequently, as the interest in computers grows, it appears that the various academic demands are met most effectively by providing two types of computers—a standard machine or machines for handling conventional problems and an experimental machine for evaluating new computer techniques and handling unconventional input or output requirements.

Experience, at least in the larger universities, has shown that once a computer is available, interest in utilizing it develops rapidly and soon computer time is at a premium. Subsequently, demands for time increase to such a point that steps must be taken to provide additional computing capacity. This problem can be approached either by obtaining additional machines of similar size or by securing a larger machine. Advantages can be cited for each alternative and numerous instances will undoubtedly arise where both steps are ultimately warranted. The availability of several smaller machines stratigically located in a university may well be more satisfying to many than a large machine in a formal computing center. A relatively recent advance which may offer a solution combining the computing efficiency of the large machine with the ready accessability to the smaller machine is provided in the use of input-out-

put consoles that can be located at several remote points about a campus so that both students and faculty can have ready access to the computer at any time.

Concluding Remarks

The technical advances in computer design and programming techniques have greatly increased the range of problems that can be handled in reasonable times and the facility with which problems can be prepared for machine solution. Furthermore, the students are eager to apply computer methods in their studies and research, and the staff, particularly the senior staff, must take the time required to acquire at least a minimum of competence in computer utilization if full advantage is to be made of the potential of computers in engineering education.

Perhaps the statement that all engineering school faculty members should be included in the spectrum of computer know-how represents an extreme view. At the same time, it would be quite dangerous to exclude the computer from any particular faculty grouping. No matter how remote the computer may appear to a given area of faculty interest, to say that the computer has no bearing is almost to say that there is no mental activity associated therewith which can be aided by machines. Indeed, to exclude even the implications of the computer from a field of endeavor requires considerable knowledge of the computer by those specialists in the particular field.

ENGINEERING DESIGN CENTER FELLOWSHIPS

Graduate students in civil, electrical, mechanical, chemical, and metallurgical engineering will be offered an opportunity to participate in the new Engineering Design Center at Case Institute of Technology, Dr. James B. Reswick, Director of the Center has announced. The educational and research activity in the Center is concerned with complex systems involving a wide variety of physical elements—electrical, mechanical, pneumatic and hydraulic—often in combination with living elements.

Basically, the Design Center at Case is an inter-departmental research and development laboratory in which groups of people undertake challenging design problems. Several laboratories already at Case will become integral parts of the Center, while others will associate in projects which are design oriented. Some of these laboratories are Propulsion and Aerodynamics, Experimental Stress Analysis, Numerical Control, Nuclear Instrumentation and Systematic Structural Synthesis.

Design teams are formed to establish a program of research and/or development so that the creative performance of each individual may be enhanced. These teams are composed of a project supervisor, design associate, project engineer, engineering design fellows, student assistants, technical associates and technical assistants.

Engineering Design Fellows, who form the main body of the design team, are candidates for the Ph.D. and M.S. degrees. A Fellow may take up to six credit hours of course work per term and divides his remaining time between teaching one course and working on his design project. Each Fellow will receive a yearly stipend of an amount commensurate with the responsibility he assumes, but the sum will not exceed $3,000 plus tuition. Academic credit is given for course work and for participation in research and development which leads to a thesis. A normal doctoral program for Engineering Design Fellows occupies four years beyond the Bachelor's degree and includes the Master's degree. The Master's program normally requires three terms. During the coming year, the first full year of the Center's operation, opportunities will be offered to 15 fellows.

Setting up a Computing Faculty in a School of Engineering

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The assigned topic of this paper requires so extensive analysis that much of the answer to the question it implies will be evident by the end of the dissection. Lacking opportunity * to discuss the meaning of "Setting up a Computing Faculty in a School of Engineering" with the unknown proposer, we take it as a general subject of interest to many engineering educators and inquire into some of its implications.

Definition

First: We assume that by "computing faculty" is meant a staff in the general field of computers and information processing, including members of non-faculty rank (e.g. instructors) as well as those of faculty rank. Whether there should be a *separate* faculty in the computer and information-processing sciences is a question which has been debated, but the proponents of a separate faculty (and department) have been relatively few though at times outspoken.

Without attempting to predict the future, we may note several substantial reasons for failure of the separate-department idea to evolve:

a) By far most students in the field, excluding those who have taken one or two courses solely to be able to use computers in their own fields of specialization, and also excluding those trained by manufacturers, have had engineering backgrounds;

b) the growing needs of the computer and information-processing sciences have been met to a large extent, although not by any means completely, by the corresponding growth of offerings in existing departments—primarily, but not entirely, in electrical engineering departments;

c) the administrative need for a separate department or faculty is not evident despite the crossing of lines of various disciplines which can be envisaged. Engineering has a plurality and probably a majority of the work, with the remainder spread among four or five non-engineering areas. But the possibility of a separate faculty (not necessarily centered in the engineering school) indicates to engineering administrators and faculties that, within accustomed intellectual standards, a pliability and acceptance of apparently unusual programs (graduate) should exist to accommodate the burgeoning field under discussion.

Second: The term *Computing Faculty* presumably refers to staff in both analogue and digital fields. There are accomplished men who are expert in one and knowledgeable in the other; the faculty member who knows both fields in a full, scholarly, sense is a rarity. There will be some small overlap, but we hypothesize that separate individuals will be needed for the separate fields.

Whether a director of an analogue computer center or the director of a digital computer center is to be included will depend on whether he is primarily a business man attempting to run a center so as to cover operating costs, or whether he is a scholar viewing his center fundamentally as a laboratory for himself and assistants and as an aid to other research. Much can be learned from the

* Through no fault of the editor of the JOURNAL, the author had available only one weekend (effectively less than one day) to write this article. Apologies are offered for lack of references, and any mistakes which may have entered what is essentially a manuscript which has missed some of the usual steps of criticism.

latter man, and without regard to title he should be included in the "computer faculty"; the business-man type of director usually does not have enough common interests to warrant this.

Third: What does the engineering school of the title want to do, what can it do, within the boundary conditions of ECPD accreditation requirements, competition of other new fields for students' time, etc.? Will the computer and information processing work contemplated be a required undergraduate course and a full graduate curriculum? Or two optional courses in an institution with no graduate work? Or some other arrangement? Is the institution large enough to support a specialized staff even if the work is confined to a single required undergraduate course, i.e., is the institution a large undergraduate teaching institution rather than a teaching *cum* research university? The setting up of a staff in any field will depend in a vital way on the answer to the last question.

There is no general rule that can be written out for setting up a computing staff in an engineering school. Barring the happy coincidence of a good man on tap when a position and funding are available, and the case of the brilliant young faculty member who develops a great enthusiasm and carries others along in his zest, the job of building up a staff in most fields of engineering is a difficult, prosaic, and plodding one despite the intellectual values involved. In the case of the computer and information-processing sciences it is made more-than-usually acute by the tremendous present industrial demand, depending in part on the widespread use of computers for military work.

Function and Scope

Returning to the basic subject of this section, there are other aspects of both undergraduate and graduate engineering education which justify a note or question. Should the computing faculty, wherever housed in the administrative structure of the engineering school, contemplate courses for all engineering undergraduates, not just those of one basic division such as EE? For those outside the engineering schools? Such a load could easily mount to large size in many cases, but it is made larger by thinking of adding the work of integrating computer and information-processing principles, or results, into existing undergraduate (as well as graduate) courses. In some respects we face a steep ramp in our evolution of courses and course content. The future has good chance of seeing the complexity of problems handled in classes of all levels increased greatly because of ability to obtain results by computer. The broadened horizon of the students will be appearing shortly in some cases—the Ford Foundation grant to the University of Michigan is evidence of the recognition of the desirability of accelerating this trend sharply. Such work is likely to fall in large part on the "computing faculty"; it will probably last for many years, and will not show in any convenient way on such vital parts of university administrative procedure as term teaching records or the equivalent. It is a glorious aspect for those who can afford it (the aspect) and them (the "computer faculty").

The blue sky is somewhat gray at the moment, but it is easily conceivable that text books of some not-far-distant time will be almost radically different from the present ones. It is far more likely that normal conservatism will make the jump a very gradual one, an unfortunate state of affairs in the view of some.

Interdisciplinary Cooperation

Fourth: We come to a ticklish question, resolved in some institutions, handled by judicious subterfuge in others, and stalemated in still others. Is Department A of the College (of liberal arts) "pure," does it recognize "applied" work, is it all-embracive, jealous of its territory, cooperative but impecunious?

In undergraduate curricula engineering schools have, by and large, no trouble in working with various departments of the College (of liberal arts) such as English, mathematics, chemistry, physics, and those in which students take optional courses. At the graduate school level this situation is often not so clean-cut. Consider for example a graduate

student judged equipped to proceed in all aspects of the computer and information-processing fields except the physical side. There exists ample work for such a man, with only a slight introduction to this physical side. His work, however, would not constitute a major in any one of the numerous departments in which he might take courses. Such a student would be a natural care of a computer faculty; if the latter is part of an EE department (for example) that department must accommodate itself to the situation or a void will exist. A decision on this score will be another vital factor in setting up a computing faculty in a school of engineering. The decision will depend to a greater or less extent on the cooperation of other (non-engineering) departments.

But more important is where will be the home of new courses which have been, are being, and will be generated for the computer and information-processing sciences. If lodged for the most part in traditional departments, the setting up of a computing faculty in a school of engineering may resolve in appreciable measure in convincing these other departments to have an appropriate man or men on their staffs. This is often dead-end work for the man involved, and particularly in the case of a "pure" department tends to take him out of the stream and spirit of main departmental activities and objectives.

If on the other hand this work reverts to the "computer faculty," then the staff requirement for it may grow and the EE or other engineering department must be prepared to have faculty members such as, for example, one who has obtained a Ph.D. through philosophy and has never had a formal course in differential equations. (Such an individual might teach an introductory computer course at one extreme, or an abstruse course in the theory of automata at the other.)

Plan of the Faculty

Fifth: A "computer faculty" is to a certain extent built around a plan. Consider the computer and information-processing fields in the light of the topics listed below, generated from a "device" viewpoint, and let the comment expand these to larger views:

(a) Research
(b) Conception
(c) Development
(d) Design
(e) Construction
(f) Principles of use
(g) Applications

(a) Research is all-pervasive. With the modern idea that research is the process that combines scholarly study or experimentation with intellectual inspiration of at least good order to produce new and significant knowledge or principles, research can exist in every step (a) to (g). [We include (a) because research into research is important in its own right and particularly important in the computer and information-processing sciences.] A new memory device is a research result of the type familiar to engineers; less familiar would be a piece of engineering research leading to radically improved efficiency in the use of an existing memory without any physical change. On the other hand the simulation of business procedures on an analogue computer may seem so natural an evolution to an engineer that he may fail to appreciate the true research that was undertaken by a person of quite different background. The extent to which research is contemplated will have an important bearing on setting up a computing faculty in an engineering school. [There is one school of thought which believes that without ample research there can be no "true" faculty, only a teaching staff.]

(b) Conception: A new computer may be conceived to meet competition, to stay ahead of competition (i.e., incorporate new research), to be part of a system, or for other purposes. If used as part of a system, there may be extensive overlap between the undefined-as-yet computer and information-processing areas and control engineering, simulation engineering, and systems engineering. Where one draws the line between these various regions of knowledge and activity will depend on local factors. The deci-

sions may well affect both the composition and size of the computer faculty.

(c) Development: Only so long as fields such as programming can be considered an engineering function can the development of computer and information-processing equipment be thought an exclusively engineering function. Too much depends on knowledge that comes from an intimate knowledge of principles of use of the equipment to be disregarded. The first large-scale electronic general-purpose digital computer (the ENIAC) had a development which included determining the sizes of the various parts; it represented a tremendous step forward. Yet many details of extended and improved use were discovered—or rather uncovered—after it was in operation. The great number of combinations of actions possible, the desirable actions which should be possible, the peculiar actions which may cause trouble—all should be taken into account in development. The extent to which it is planned to include this aspect in the work of the hypothetical "computing faculty" will affect the size and composition of the latter. More is said on this score under (f) below.

(d) Design: There are usually two steps in design, logical design and equipment or component design. The division results from the complexity of the devices, the logical design (or logic design as it is often called) being something in the nature of a detailed block diagram which the equipment designers can follow to formulate the actual circuits and other assemblies or components of the proposed machine. Logic design should ideally be carried out with full knowledge of the ranges which the equipment designer can achieve as well as knowledge of the basic logic of the contemplated device; unfortunately logic design has fallen to a low state in some instances.

But logic design would almost certainly be part of the work of a computing faculty, whereas equipment or component design raises a quite different question. The analytical principles on which the latter is based are incorporated and integrated for the most part in existing courses not specially set up for computer applications. Advanced courses, still devoted to analytical principles but treating in depth various topics of interest in the computer and information-processing fields, are based on the first courses but represent reasonable continuations. (Practice we assume assigned to industry, hence disregard here.) The extent to which a computing faculty—say a subgroup of the EE faculty—goes into this question is again one of compromise and cooperation. It is likely that if a subgroup of the EE faculty constituted what is here called the computing faculty, it would contain many members of the EE faculty not primarily interested in computers but giving work on which specialized computer work is based.

This point offers an opportunity to bring in the question of human factors. Computer and information-processing equipment in general is extremely complicated. There are other systems in which there are more transistors, resistors, etc., but none except computers in which the operation of the entire system depends on the satisfactory operation of almost all elementary components and units. With only a given number of persons in the country with IQ's between x and y, or simply above x, a machine should not be so complicated in operation, maintenance, repair, etc., that it and its duplicates require more persons with IQ's above x than are likely to be available. This begins a trade-off procedure in which the human factors specialist is important. Increased complexity reduces reliability and increases IQ requirements for operators, programmers, maintenance men, etc. There are topics in systems engineering which should be represented by a man on a "computing faculty" of appreciable stature, either through cooperation with a psychology department or otherwise.

(e) Construction: Engineers in factory production or other construction of equipment related to computers need certain specialized knowledge and a knowledge roughly (and lightly) similar to that of the equipment designer. To take an example, cross-talk can be radically altered by an apparently extremely minor

change in production. We see, however, no particular new question here which affects our hypothetical computing faculty.

(f) Principles of Use: This section discusses principles of use, a phrase which should be carefully distinguished from "applications." Machines, except simple desk calculators and similar devices, are used by being programmed. This is a principle, but all programming would not be likely to be the care of our "computing faculty." Much programming is routine, and girls with education limited to high-school graduation are being successfully taught programming for digital machines. The semantic hitch is that the word covers many levels of effort. There does not appear to be an adequate classification of programming levels. We will have to be satisfied by saying our concern is at the higher levels, and leave the stratification to the human factors people for later development (this is being considered on a major scale now; some firms with large numbers of programmers have their local classifications).

Any complete program for a digital computer is roughly equivalent to the logical design of a special-purpose machine. A very large number of such complete programs for a specialized application (e.g., insurance) may lead to the specification of a special-purpose machine which is a general-purpose machine within one broad field (e.g. insurance).

The familiar sequence bits, characters, words, commands, queries, sentences, etc., as well as the word codes lead to the top echelon of programming, namely machine languages. Study in this area begins to parallel rather closely work in linguistics, and a "computing faculty" will either have its own specialists or work closely with an interested linguistics department.

We come to the point where our "computing faculty" has a basic interest in programming from a number of different points of view. Furthermore it is a field in which specialization is possible, within the computer field. It is also a field which may be entered via linguistics for example, although most upper-bracket programmers have a background in mathematics. It is in connection with people such as these that a computing faculty in a school of engineering, and the department with which it may be associated, must be prepared to open their arms to the qualified non-engineer. Interestingly enough, in the long run there is a close similarity between the manipulation of non-numerical symbols of the advanced programmer and the manipulation of mathematical symbols in engineering analysis, but there is probably a closer analogy with the work of analytical linguistics, and possibly there is a philosophy department in the background believing the work has many points of contact with some of its own.

(g) Applications: When one thinks of the many uses of computers—for engineering (usually called scientific) problems, business and industry applications, control, natural language translation, psychological experimentation, gaming, and others—it seems reasonable to expect persons in the non-engineering fields to learn the rudiments and from there on do their own work. This leaves to our hypothetical computing faculty in a school of engineering a basic course or two, suitable to many with diverse backgrounds, and at least some detail on scientific problems. The latter invariably leads to numerical analysis which will fall either to the mathematics department (if interested) or to the computing faculty. There is no loss—at least at the graduate level—in having this the latter way, and there may be some gain in efficiency. For scientific applications it is essential and in some aspects it is presumably the moral if not "actual" responsibility of our hypothetical computing faculty to see that numerical analysis is given in proper form and level.

One other area of application which the "computing faculty" might consider is the business field. Here the number of students may be so large that a cooperative effort with the school of business administration might help support an extra member or so of the computing faculty while keeping the group in touch with interesting major practical problems such as inventory control where large information retrieval systems are needed.

Sixth: The non-engineering departments which may be concerned are mathematics, linguistics, psychology, and philosophy, and the school of business administration-mathematics for numerous topics some of which were mentioned above, linguistics for association with top-level programming theory, psychology because of apparently intense interest coupled with a few predictions that some years from now a large amount of psychological experimentation will be on computers, philosophy because there are close ties at several places beginning way back with that word *logic* in logic design, and the school of business administration because potentially large numbers of students deserve help and contribute to the support of the "computing faculty."

In engineering there is support needed by way of many EE standard subjects (since most medium and large computers and information processors are on the whole electronic devices), plus information theory, switching theory, noise theory, automata theory, and so on.

Conclusion

This paper has endeavored to give in extremely brief form some ideas which go to estimating the background for a faculty group in the specialized field of the computer and information-processing sciences.

There is no set of rules for setting up a faculty group. Each situation is substantially unique, and depends on availability of funds, scope of proposed work, size of anticipated student body, cooperation (or lack) between departments, and many other factors. About all that can be said is that the creation or extension of a "computing faculty" group is much like that for any other new and important subdivision of engineering effort.

No mention has been made of the possible help which government contracts might offer in initiating or expanding programs, and no mention is necessary. But engineering educators might consider whether in their opinions more such contracts for the universities might not yield a greater than proportionate social return.

RODES NEW GMI PRESIDENT

Appointment of Dr. Harold P. Rodes as president of General Motors Institute, Flint, Michigan, has been announced by James E. Goodman, chairman of the Institute's board of regents and vice president of General Motors.

Dr. Rodes, president of Bradley University, Peoria, Illinois, since 1954, will succeed Guy R. Cowing at the end of the current GMI school term in August. Mr. Cowing, head of the Institute since 1950 and a member of its faculty for 34 years, will retire under provisions of the General Motors Retirement Program.

General Motors Institute is the center for educational activities of General Motors Corporation. It is the largest industrial educational institution of its kind in the world, with an enrollment of 2,500 undergraduate engineering students in a five-year cooperative program. Additionally, some 26,000 GM employees in plants throughout the world are enrolled in part-time programs. Approximately 3,600 GMI co-op graduates are currently employed by General Motors.

Computer Design Courses in the Engineering Curriculum

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The problem of how best to incorporate recent advances in technology into the engineering curriculum is one which is arising more and more frequently. Electrical engineering faculties, for instance, have had to consider in recent years how to absorb such topics as radar, television, transistors, solid state physics, feedback control systems, and computers, among others. Some new topics can best be treated by making small changes to adapt existing courses to them, others may require introduction of new courses, and still others may be of sufficient importance to justify the addition of complete new curricula and degree programs. The engineering of digital computers was initially presented merely by devoting a few lectures to it in advanced electronic circuits courses. During the 1950's many universities introduced groups of new courses in this area, and there is at present at least one school (Arizona State University) that grants a bachelor's degree in computer engineering.

The Need and the Problems

What justification is there for devoting many courses or even a degree program to the engineering of the digital computer? There are, after all, many large engineering design tasks which are fully as intricate and costly as a computer but which are scarcely mentioned in an engineering curriculum. The distinctive feature of the digital computer is that it is a tool, and indeed a very powerful tool, which is useful not only to engineers, but to workers in all the physical sciences, in the life sciences, in the social sciences, in business, in industry, in government, in management, and in every place where there is a problem to be solved or a situation to be simulated to find its behavior. The computer is not simply a device for doing a lot of arithmetic in a hurry. It is a general-purpose system which can solve any problem or imitate the behavior of any process, provided only that an "effective" description of the problem or process can be set down. The process, or even its description, need not be numerical, although of course the words or pictures used in the description must be represented in the computer by digital symbols.

So powerful and useful a device obviously deserves an important place in the engineering curriculum, and many efforts are being made to train all engineers in the use of computers. At the same time the very challenging design problems associated with such powerful systems must also be treated, and it is with this treatment that this paper is primarily concerned. Electrical engineering faculties must find answers to such questions as:

1. What laboratory facilities are needed to teach the essentials of digital computer engineering?
2. To what extent should the engineering of analog computers be given special treatment, or can the subject be best presented in existing courses by including material on d-c amplifiers and on the stabilization of high-gain feedback amplifiers?
3. Should every electrical engineer be exposed to the problem of computer design, or should such material be in elective courses?
4. Should all electrical engineers (and indeed, all engineers) be required to learn how to use both the analog and the digital computer?

5. Should the electrical engineer's training in the use of computers be different from that of other engineers?

6. What material is appropriate to computer engineering courses at the undergraduate level and at the graduate level?

7. What related material should be taught within the electrical engineering department, and what material should be presented instead by other departments, e.g., departments of mathematics or of philosophy?

The Program at Michigan

Of course, it is not possible to give answers to these questions which will be equally valid for all universities. Since this is so, we shall follow an alternative procedure of describing and commenting upon the existing curriculum at the University of Michigan, where courses in the engineering of computers have been presented since 1951. This experience may be of some interest to the reader, although the curriculum presented here makes no pretensions to being the ideal one.

Before discussing computer engineering courses, however, let us consider briefly the matter of courses in the use of computers. It is the writer's firm opinion that every engineer should receive training in the use of both analog and digital computers during his undergraduate years. Since analog computers are comparatively inexpensive devices (a small but useful analog computer can be purchased for as little as two or three thousand dollars), it is practical to distribute several of these units among the various instructional departments, allowing each department to use the equipment as it sees fit and to introduce the computer in whatever courses and at whatever points it wishes.

The least expensive digital computers, however, cost ten to twenty times as much as the simplest analog computer and hence cannot be made so freely available. Some sort of central computing facility is ordinarily established, and instruction in the use of this equipment seems best suited to presentation in a single course on computer programming and use instead of being spread through various engineering courses. Such a course has been presented during the past year at the University of Michigan by the Department of Mathematics. This course is a one-credit-hour course and is designed for engineering students at the sophomore or junior level. It is hoped that within another two years this course may be a required part of all engineering curricula, thus making it possible for engineering instructors to assume that all senior students, at least, have sufficient computer knowledge to use the computer as a tool.

Program for Electrical Engineers

Among all engineers the electrical engineer stands in a unique relation to the electronic computer, since he is both user and builder. Thus, up to the present, the first course in computers which our electrical engineers take at Michigan has been one which presents the principles of both the use and the design of each of the two major classes of computers, the analog computer (specifically, the electronic differential analyzer), and the digital computer. This course, called "Analog and Digital Computer Technology," is a 3 credit-hour course presented to seniors and beginning graduate students. It is intended to serve as an introductory course both for those who wish to continue to more advanced courses and for those who wish merely to acquire a broad background in the field before leaving the University. About one-third of the course is devoted to analog computers and the remainder to digital computers.

This course, which has now been presented for nearly nine years, has demonstrated two facts: (1) student interest in computers is enormous, and (2) one or more computer courses should be available as electives for electrical engineers in their junior year, instead of obliging them to wait until their senior year. Consequently, in the fall semester of 1960, two new courses open to juniors will be presented. These courses are to be called "Introduction to the Design and Engineering Application of Computers" and "Switching Circuits and Log-

ical Design." It is anticipated that while these courses may initially result in a drop in the enrollment in the Analog and Digital Computer Technology course, they will ultimately increase the enrollment in this and more advanced courses, since more students will be introduced to the subject earlier, and they will also allow the advanced courses to be conducted at a more advanced level.

The advanced courses are the ones in which the significant material about computer design and organization can be presented. The writer feels that computer engineering requires a broad background in electrical engineering and a high level of mathematical maturity. Students who have reached this point are usually by that time seniors or graduate students and hence such courses are best offered at the graduate level. Computer engineering, like nuclear engineering, appears to be better suited for presentation as an area of graduate specialization rather than as a basic undergraduate curriculum.

Graduate Courses

The subject matter for graduate courses in computer design and engineering falls into two broad categories, one consisting of the more abstract and general material and the other comprising the more specific and concrete. Among the more abstract topics may be listed the following:

1. The postulate approach to definition of mathematical systems.
2. Symbolic logic, Boolean algebra, and the design of combinational switching circuits.
3. State diagrams, equivalent states, and sequential switching circuits.
4. Theory of automata—finite or infinite, fixed or growing.
5. Finite number systems.

The more specific subjects are those which are more closely related to the current technology of computer design and include such topics as the following:

1. Logical circuits for the various control functions in the computer.
2. Arithmetic processes—adders, subtractors, carry propagation, high-speed arithmetic, roundoff, methods of multiplication, division, square root.
3. Command lists for general-purpose computers.
4. Relation of internal and external languages.
5. Memory systems—ferrite cores, thin magnetic films.
6. Means of implementing computer logic—transistors, cryotrons, flux logic devices.

These two lists of topics can be fitted quite effectively into two one-semester courses of three credit hours each. Of course, given sufficient teaching staff and student enrollment, each of these two groups of topics could be broken up into several courses. However, two courses fill the needs of most graduate students very nicely, especially when supplemented by philosophy or mathematics courses in symbolic logic, modern algebra, number theory, and possibly topology. Two courses covering these lists of topics are sufficient to acquaint the computer engineer with the most modern techniques and tools for synthesis of computer systems as well as with many of the challenging and pressing research problems at the frontiers of existing knowledge about computers. It is also worth noting that two courses organized along these lines can be conducted more or less independently, if desired, and there is no real necessity to make either course be a prerequisite for the other.

To conclude our discussion some comments should be made about the laboratory facilities needed for graduate work in computer engineering. The University of Michigan is particularly fortunate in this regard, since one of the principal tools in its Digital Computer Engineering Laboratory is a computer (MIC—Michigan Instructional Computer) which is used solely by electrical engineering students studying the logical organization and structure of computers. The logic of this machine is completely pluggable, so that students can study the existing logic or alter the system at will. The machine is not part of the University's computation service and hence need not be protected from engineers probing its insides. Indeed, the machine is most

useful when it is not in condition to compute and students are changing its circuits.

Although such a facility can be a wonderfully useful one, it is not necessary to have a complete computer available for experiments with logical circuits. It is highly desirable, however, to have available enough logical "building blocks" to allow students to build up working circuits to do each of the control and arithmetic functions of a computer. These logical elements can be any of the many excellent logical elements now on the market, which range in speed from 10kc. at the low end to 5 mc. at the upper extreme. Some laboratories may even be able to provide their students two or three types of logical elements.

In addition to the logical elements, suitable oscilloscopes must be provided. Small-scale models of various memory systems can be useful, as well as a quantity of ferrite memory cores which can be studied individually or wired up in various forms of matrices. At Michigan, computer laboratory work is presented as a separate course. Others might prefer to make it a part of one of the other courses.

A final point which should be noted is that courses in the engineering of computers must not overemphasize the technology of today. Computer engineering is scarcely in its second decade, and no one can predict what today's students will be doing in this area twenty years after their graduation. Although students must receive enough training in today's techniques to permit them to recognize the computer world about them when they graduate, it is more important that they have a sound grasp of those mathematical and physical principles which will enable them to comprehend the development of computer technology and to contribute to it themselves.

YOUTH AND THE SPACE SCIENCES

The Institute of Aeronautical Sciences, the American Rocket Society, and ASEE will have a joint session on June 29 in the Hotel Ambassador in Los Angeles. Subject of the meeting will be the problems of youth in the space sciences. Speakers will be J. H. Browne, Director of the Exploring Service of the Boy Scouts of America; Dr. R. Richardson of the Los Angeles Board of Education; L. Stockford from industry; and D. W. Cecka of the American Rocket Society. Dr. Vincent S. Hanneman, Jr., Engineering Consultant, Dallas, Texas, has arranged the session and will chair the meeting.

WOOLRICH WRITES ON MIDDLE EAST UNIVERSITY

The article, "A New Middle Eastern University with Modern Western World Objectives," on page 703 of our May issue, was written by Dean W. R. Woolrich of the University of Texas, recently returned from acting as Interim President for Middle East Technical University. The error in authorship was the result of a misunderstanding and the time necessary for mail service between Illinois and Turkey. The JOURNAL offers its apologies to Dean Woolrich and to Miss Horobin.

Numerical Analysis and Computers in Engineering Education

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The Computer Revolution is being talked and written about in a phenomenally wide range of collections of people and types of literature. Being in an engineering school, I've frequently made the assertion that every graduating engineer should have training on a computer before he finishes college. Almost as frequently, I have been called down by comments that are summed up by the following: "It's not just the engineering student but also the science, business, economics, library, language and social science students who should have computer training." This simply serves all the more to emphasize the impact of this revolution on the engineering field, as well as to increase the responsibility of engineering departments to develop the whole area of computers and their use.

The concept that every engineer should have computer training is pretty generally accepted now. The degree of acceptance of the concept, the methods of accomplishing it and the motivations for carrying it through in a truly effective manner are, however, not uniform. These vary widely and depend on such things as the availability of computer time; the computer background training of the people in the school; the willingness of the school administration to accept new ideas; the location of the computer center within the administrative organization; the availability of financial support for the center; the cooperation of key departments such as Mathematics and Electrical Engineering; and the readiness and ability of the computer center personnel to fulfill its mission. If all the above factors are favorable, the question still arises as to what is the best way of accomplishing this computer training? I believe this requires careful planning on the part of the computer center and the various engineering schools in cooperation with the Mathematics Department. The role of the latter is in supplying the necessary background training in mathematics and especially in numerical analysis.

Theory but with Practice

Numerical analysis has been defined as the art and science of preparing and solving scientific and engineering problems by means of digital computation (1). Such a definition is very broad and includes most of the mathematics useful to engineers, since most of their mathematical problems can be reduced to a form amenable to machine solution. This is done by describing the problem in terms of an algorithm or flow chart. This process itself is extremely important. Once a student (or instructor) on his own has told a computer exactly how to solve a problem, he has a thorough understanding of just what the problem is and how it is solved. This is an understanding which goes far beyond just knowing the theory of the problem or process. As faith without works is dead, so theory without practice is sterile.

The general question of numerical analysis in an undergraduate program has been discussed very well by Forsythe (1). He appeals for an integration of more numerical analysis into the standard courses in mathematics, emphasizing, however, that this is certainly not to be done at the expense of a thorough understanding of the broad structure of mathematics. This kind of understanding is essential to the application of the principles under varied circumstances. I

certainly concur in the trend toward the introduction of more abstract ideas in the mathematics curriculum but, at the same time, feel that there is a very grave danger of doing this at the cost of presenting concrete examples. I believe that a great injustice has been done to the student who has been exposed to pure theory or abstraction for a full semester (or quarter) with only a few token examples interpolated to soothe the conscience of the instructor. I feel very strongly about this point because I have been in the position of having heard practicing mathematicians say that they received their Ph.D. from such-and-such a university but they had been taught no mathematics which they could actually put to use.

The cry from engineers has been even more tragic. To illustrate in part what I am saying, I had a very capable engineer say to me recently, "Why can't they give us more numerical methods in courses in differential equations, and perhaps cut out some of those numerous methods we can never use anyway? I think that in many mathematics courses, such as differential equations, they should enter parallel solutions—on the one side the analytic solution, if such perchance is possible, and on the other side a numerical solution." As another illustration, it clearly is no longer sufficient to point out to a student that the trajectory of a missile is a parabola, or that the orbit of a satellite is an ellipse. It must be remembered that it is a genuine stimulus and motivation to the engineer to realize that there is a down-to-earth real use and practical value to the mathematics he is learning. Tukey has presented a further discussion on the teaching of concrete mathematics which is very valuable (2).

While I have been very critical of the mathematician who has a tendency to be too abstract, I would be equally critical of the engineers who resist any theoretical or abstract mathematics, and even more critical of those who resist any mathematics beyond the basic elements of calculus. Most fields of engineering, if pursued now to any advanced degree of understanding, employ some of the most modern tools of mathematics. It is not an uncommon occurrence now to find a Ph.D. student in an engineering field going to the current literature in mathematics and finding it inadequate for his purposes. He is then forced to improvise or invent for himself. This clearly means that it is much better for such a student to have a thorough grounding in the necessary basic mathematics, and in as general a form as possible, so that he has a firm foundation on which to build.

Information Processing Department

There is developing from a number of quarters a fairly strong chorus of voices calling for a new department within the university, devoted to coordinating all the various aspects of computing. The most likely choice of a name for such a department would currently be the Information Processing Department. This title would be in line with the June 1959 International Conference on Information Processing held in Paris, and the recently formed International Federation of Information Processing Societies under the auspices of UNESCO. While I believe such an idea to be feasible, I also believe that it will be quite some time before many schools are in a position to set up such a department. It does behoove all of us, however, to keep such an idea in mind and do a certain amount of planning toward it. If for no other reason, it will help crystallize in our own minds the integral role computers can play.

The potential engineer should most certainly be encouraged, if not required, to learn to use a computer at the earliest possible moment in his career. I believe that the time is here—or at least almost here—when it is just as important for the engineer to know how to use a digital computer as it is to use a slide rule. Some would contend that the training on a computer should start as a freshman. I would not argue much with this, but would be more inclined to start in the sophomore year after the student has completed that first year of orientation to college life. He should then attend a course in programming and coding which is sufficiently complete to give him an understanding and appreciation of how a computer operates, and permit him to

actually solve several problems on the computer, not necessarily complex ones. The course should clearly emphasize the idea of drawing a careful flow chart for the work. By so doing, he can be taught a great deal about planning and organization of his work—something which is extremely valuable in any discipline. To accomplish this, the equivalent of a two-hour course for not more than one quarter is sufficient. It is my belief that the coding in this course should be taught by use of the best compiler (or interpretive) system available for the computer at that school. It is hoped that very soon the new compiler ALGOL will be available on all computers so that there will be a uniformity on an international basis of the computer language being used.

After this initial computer training, I would hope that the student would be able to employ and advance this training in a wide variety of his courses. Certainly I would want him to apply it in his mathematics courses and receive from his instructor in those courses some guidance on such fundamental things as significant digits, approximation theory, error analysis and other applications of numerical analysis. See Section 7 of (1), and the latter half of Householder's discussion (3). Since realistically it will be some time before a great deal of practical numerical analysis is interpolated into the revised standard courses in mathematics, it will be advisable for a fairly large number of engineering students to take formal courses in numerical analysis. Civil engineers, electrical engineers, chemical engineers, and others will seriously need numerical methods for the solution of systems of linear and occasionally systems of non-linear equations. Chemical engineers, mechanical engineers, and nuclear engineers will also need methods for the numerical solution of partial differential equations. Most engineers (if they go very far at all) will need some approximation theory, interpolation, and the numerical solution of ordinary differential equations. *Modern Computing Methods* (4), Hildebrand (5), and Milne (6), or combinations of these are suggested as possible texts, though many others are available to suit the individual tastes of the instructor.

Civil Engineering

In each of the individual engineering fields, I would hope that at least one and preferably several courses would employ the computer as a means of solving some of their problems. They would be able to assign much more realistic problems and at the same time give the student a feeling for the application of a computer in his field. As a first example, I would like to cite the Civil Engineering School here at Georgia Tech. In one of their structure courses, the students are asked to use the computer in solving problems in linear algebra they could not easily work out by hand. Similarly, in one of the aerial photogrammetry courses, all of the problems in the first part of the course are worked on a desk calculator, but the problems assigned in the latter part of the course must be solved on the digital computer. This latter example illustrates the important point that a student should learn to solve problems on a desk calculator before he gets on a high-speed digital computer. It not only adds to his understanding of the problems of computation, but also adds to his appreciation of what the modern computer can do for him. The several thousand operations per second he can get on a high-speed computer versus his three or four per minute on a desk calculator can make a lasting impression on him.

Before leaving civil engineering, I would like to cite the May, 1958, issue of *Civil Engineering*, which was devoted primarily to electronic computation. The tone was set by Newmark (7) as he asserted that the high-speed electronic digital computer has brought about a revolution in engineering analysis and design. With this new tool now available, it is possible to do a much more complete job of analysis and come up with far better designs. This will mean, speaking somewhat figuratively, that the engineer will not have to have a 100% safety factor in his design but can perhaps reduce it to a 10% safety factor. This, in turn, will raise many more questions about the materials being used and,

consequently, lead to more research in this area. Looking more deeply into the structure is, in turn, going to increase the need for more rigorous numerical analysis. Needless to say, this general concept is not restricted to civil engineering. It has obvious applications to aeronautical engineering, chemical engineering, electrical engineering, mechanical engineering and others. One of my colleagues asserted very wisely that engineering in the past has been a study of first order phenomena. Now with computers and the new methods at our disposal, it can, and is, including second and third order phenomena.

Other Fields of Engineering

Civil engineering is certainly not the only field that has been publicizing its use of computers. There have been very similar spreads about computers in other engineering publications. Among these is the May, 1958, issue of *Nucleonics,* which contains a special report on analog and digital computers in nuclear engineering. The March issues of the *Journal of Industrial and Engineering Chemistry* contain annual reviews of computers and mathematics. This has been occurring for several years.

I would like to cite a few courses or areas in some of the various fields of engineering where the computer can be used to advantage in both the undergraduate and graduate programs for the solution of some of the more complex problems.

(a) *Aeronautical Engineering:* aerodynamics, theory of aircraft structure, airplane design, and dynamics of the airplane.

(b) *Chemical Engineering:* chemical engineering calculations, applied chemical kinetics, fluid flow, heat transmission, unit operations, and thermodynamics.

(c) *Civil Engineering:* structural analysis and design, fluid mechanics, reinforced concrete structure and design, metal structure design, hydraulics, and aerial photogrammetry.

(d) *Electrical Engineering:* circuit analysis and synthesis, electromagnetic field theory, electrical transients, servomechanisms, and switching circuits.

(e) *Engineering Mechanics:* mechanics of materials, dynamics, and mechanical vibration.

(f) *Industrial Engineering:* production control, quality control, linear programming and operations research.

(g) *Mechanical Engineering:* fluid mechanics, heat transfer, thermodynamics, and machine design.

In summary, the engineer who graduates and goes out into industry now without any computer training is starting with a handicap. It is now imperative that he learn how to use computers for their value as a time-saving device on standard problems, as a tool for solving problems numerically that could not otherwise be solved, as a tool for analysis and design that is revolutionizing industry, as an integral link in the rapidly changing field of instrumentation and control, and as an indispensable aid in the processing of economics and business information. He must, at the same time, learn to use the computer wisely. With computers that can turn out up to 5,000 lines a minute, he can easily be swamped with more "information" than he can possibly use. He must also realize that as wonderful as computers are, they are still no substitute for thinking!

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The Use of a Modern Computer as a Teaching Aid in Structural Analysis and Design

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Many excellent papers have been written in the past few years on the use of high speed digital computers in the field of structural analysis. Most of them have been slanted, and rightly so, toward consulting engineering firms, in an attempt to encourage justifiable and economic use of computers in overcoming much of the drudgery present in modern analysis and design. Because many of our universities now have medium sized computers available for use in both teaching and research programs, the writer believes it is now economically practical to make use of these machines as teaching aids in both graduate and undergraduate courses in structural analysis and design.

The analysis of highly indeterminate structures is a complicated and difficult procedure. Much of the difficulty is due to the fact that many simultaneous equations must be solved, and special solutions containing short cuts or simplifying assumptions have been applied. In the usual methods used for solving simultaneous equations, such as the various iterative procedures or that of relaxation, the time required increases rapidly with the number of unknowns and often a suitably quick convergence is not possible. Neglect of certain effects, such as that of axial forces in members of rigid frames, in an attempt to either reduce the number of unknowns or speed up the convergence, has often produced questionable results or a final over-design. In many instances, the matter of stability has been ignored completely because of a lack of ability to cope with it and the flexural and axial effects concurrently.

The advent of the modern high speed electronic computer has once again caused the engineering profession to undergo a transition similar to that when the sliderule gave way—at least partially—to the desk calculator. Mathematical computations being carried out on a desk calculator are performed with tremendous speed on the electronic computer. Much of the time consumed in menial calculating is gained by the use of a computer and the engineer is free to do his true and creative work. But perhaps more important to the structural engineer is the fact that the solution of simultaneous equations is no longer a deterrent to proper structural analysis. Digital computers can solve large numbers of simultaneous equations in a matter of minutes and therefore the engineer's primary tool, mathematics, can be used to far greater advantage than before. Many of the simplifying assumptions are unnecessary and no longer must certain effects be neglected.

New Tools—New Methods

As so often happens when a new tool is put into use, a new method of obtaining the desired result may be necessary to realize fully the capabilities of the tool. In the case of the modern digital computer, a somewhat different and perhaps unfamiliar mathematical approach is necessary in order to systematize structural calculations for computer solution. The use of matrix algebra seems to provide a simple and easily applied method of obtaining the desired end result.

Consider the general case of a prismatic bar subjected to positive end loadings of moment, shear and axial force as shown in Figure 1. The differential

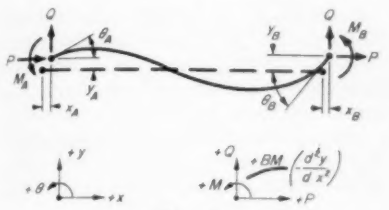

FIG. 1.

equation of the deflection curve is given by

$$M = Py - Qx + M_A = -EI\frac{d^2y}{dx^2},$$

from which the relations between the loads and deformations are derived as

$$M_A = \left(\frac{6EI}{L^2}\varphi_2\right)(y_A - y_B) + \left(\frac{4EI}{L}\varphi_3\right)\theta_A + \left(\frac{2EI}{L}\varphi_4\right)\theta_B,$$

$$M_B = \left(\frac{6EI}{L^2}\varphi_2\right)(y_A - y_B) + \left(\frac{2EI}{L}\varphi_4\right)\theta_A + \left(\frac{4EI}{L}\varphi_3\right)\theta_B,$$

$$Q = \left(\frac{12EI}{L^3}\varphi_5\right)(y_A - y_B) + \left(\frac{6EI}{L^2}\varphi_2\right)\theta_A + \left(\frac{6EI}{L^2}\varphi_2\right)\theta_B,$$

$$P = \frac{EA}{L}(x_A - x_B),$$

where the functions φ are the so called stability functions[1] as discussed by Livesley.[2] It is to be noted that for the case of no axial load ($P = O$), the φ functions will all be unity and the above equations reduce to the well known slope-deflection equations.

These four equations can be applied to simple and restrained beams, to pin-ended and rigid trusses, to rigid frames, and could be extended to include space structures of most types. Problems in elastic stability and critical load can also be solved. However, the use of these equations does not become generally practical or economical unless a fast method of solution is available. The high speed digital computer is the tool which often makes this possible.

Standard programs for the analysis of beams, trusses, and rigid frames have been written for many of the medium sized computers. These could be briefly explained and an example (perhaps a problem the students have done by a relaxation method such as moment distribution) actually run for students in elementary structural analysis so that they can get some notion of how this new tool works and of its value in certain phases of structural analysis and design. Those students who desire to know more about digital computers should perhaps be encouraged to take the elementary course now offered in many schools covering the operation and programming of computing machines.

A digital computer can also be advantageous to the professor in reducing his time in preparation of problems for more effective classroom assignments. For example, the rigid frame shown in Figure 2 could be assigned for solution by the method of moment distribution. Each student could be given a different value for the load P, thus helping to insure independent work on the part of the student. The instructor would be required, therefore, to have as many solutions as he has students—a time consuming task if done by conventional moment distribution methods. However, with the aid of the digital computer, the neces-

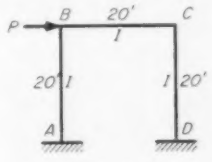

FIG. 2.

[1] The stability functions are related to the Berry functions tabulated by Timoshenko in his *Theory of Elastic Stability*, McGraw-Hill, 1936, pp. 499 ff.

[2] R. K. Livesley, "The application of an electronic digital computer to some problems of structural analysis," *The Structural Engineer*, Vol. XXXIV, No. 1, Jan. 1956, p. 1.

sary solutions are obtained in a matter of minutes and the students' problems checked as easily as for a single assigned problem given to all. A computer program for the IBM 650 for the solution of single bay, rigid frame bents, suitable for this purpose as well as for illustrating computer analysis to students, has been developed and used successfully by the writer.[3]

In summary, it is both practical and economical to give a brief introduction to the use of digital computers in structural analysis courses for undergraduate students. In those institutions which have a computer available, it is recommended that the engineering faculties avail themselves of the machine as an aid to more effective and timely teaching.

[3] L. D. Luck, "Rigid Frame Analysis by Matrix Methods with the Aid of a Digital Computer," paper presented before the Structural Engineers Association of Northern California, San Franciso, May 5, 1959.

NEW MATRIC CALCULUS COMPUTER

The first matric calculus computer to work with both general matric equations and with differential and integral calculus equations has been developed by Pierre M. Honnell, professor of electrical engineering at Washington University, St. Louis, and his doctoral students.

An expanded program of research on development of the computer got underway last fall in a computing devices research laboratory which is being established in the school's new Engineering Laboratory Building.

While digital computers use the fundamental mathematical concepts of adding and subtracting almost exclusively in their operation, matric equation analyzers work with entire equation systems instead. The matric calculus computer designed by Honnell is the first to work with general matrix equations as well as with differential and some integral, calculus equations. Advantages of the matric calculus are conciseness and generability of notation, high analytical power and wide applicability. Formerly used primarily in mathematical research, matric methods now are applied with increasing frequency to scientific problems in physics, dynamics, electric networks and econometrics.

The theory behind Honnell's computer is based on the synthesis of electronic (i.e.) active networks on an admittance basis. The basis is such that each matric entry of the mathematical equations being solved is represented by only one physical component in the synthesis network. A complete homeomorphism or 1-to-1 correspondence exists, which theoretically can be made as exact as desired, between physical network components and mathematical matrix entries.

Honnell's theory synthesizes networks which exhibit the solutions of matrically-formulated mathematical problems, such as systems of differential equations.

The electronic synthesis networks can be ordered physically to show a complete isomorphism between the adjustable physical network components and the mathematical elements of the problem to be solved. In other words, the machine problem control panel can be designed in the typical mathematical matric array. This yields a matric calculus computer with all the advantages and flexibility of matric methods of computation. The computer can be used by the mathematician and the mathematically educated scientist or engineer, without need for an electronics interpreter.

The Evaluation of Teaching

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At the annual meeting of the American Association of Land Grant Colleges and State Universities last November, one presentation attracting a great deal of attention was that of Ralph W. Tyler, who spoke on the evaluation of teaching. Of particular interest to his listeners was his discussion of the necessary conditions for effective learning, which he listed under nine headings.

The material in Mr. Tyler's talk has been published by the University of Minnesota Press as a chapter in a book, *The Two Ends of the Log, Learning and Teaching in Today's Colleges,* edited by Russell M. Cooper.[1] The book is based on a series of papers presented at a conference on college teaching held at the University of Minnesota under the sponsorship of the Association of Minnesota Colleges.

Because of the wide interest expressed in Mr. Tyler's list of the conditions of learning, the JOURNAL has obtained permission from the University of Minnesota Press to reprint that section of his paper. Other salient points are made in Mr. Tyler's paper, and the reader who finds this excerpt interesting would find it worthwhile to obtain a copy of the book and read the paper in its entirety, along with the other excellent chapters in the same volume.

Although the appraisal of students' learning is the most direct and the ultimate evaluation of teaching, there are other less direct methods which are useful. One of these is to examine the extent to which the conditions for effective learning are provided. Over the years psychologists, other social scientists, and educational practitioners have learned a great deal about the conditions necessary for effective learning. Since effective teaching consists largely of providing the conditions for effective learning, it is possible to make an indirect, but highly relevant, evaluation of teaching by noting the extent to which essential conditions for learning are actually present. In psychological literature one will find a number of lists of essential conditions, but most of the lists contain very similar elements.

One necessary condition is the student's motivation. The learner learns what he is thinking, feeling, or doing. Thus learning is not possible except as the learner himself is involved in it. This makes his motivation—that is, the impelling force for his own active involvement—a very important condition. In any college class, or in the college as a whole, it is possible to find out something about students' motivation. What proportion of them are interested in their studies? Are they deeply involved in the work of the class? Does the intellectual activity of the college represent a real concern on the part of the students, and for what fraction of the student body? These are typical questions that can be raised, and largely answered, by observation, interviewing, and the like.

A second condition for effective learning is that the learner finds his previous ways of reacting unsatisfactory so that he is stimulated to try new ways of reacting. As long as the learner does not recognize that earlier modes of behavior are inappropriate, he will keep on doing what he has been doing before and will not really learn anything new. It is necessary for him to discover the inadequacy of his previous behavior in order that he will not continue to repeat it. College students often carry over from their

[1] University of Minnesota Press, Minneapolis 14, Minnesota. Four dollars.

earlier school experiences the notion that study is memorization; called upon to study in college courses, they try to memorize textbook materials. The college teacher must help the student discover that memorization is not a satisfactory means to solve the kinds of problems or do the sorts of exercises which the college class requires. In seeking to evaluate teaching in a college one may ask, "What proportion of the students recognize the fact that they are facing new problems and require new understanding, new techniques, and new attitudes in order to deal with these problems effectively?"

A third condition is for the learner to have some guidance of the new behavior which he tries in seeking to overcome the inadequacy of previous reactions. If he simply tries new behavior by trial and error, learning is very slow and he is often discouraged and gives up. Some means of indicating to him more promising reactions will serve to guide him. Many ways are used to guide the learner in helping him to understand. Parts of syllabuses, textbooks, and manuals may be prepared or selected for this purpose. The instructor may ask questions which lead the student to look at various elements that he may have previously overlooked in his search for meaningful relations. He may be aided in learning a skill by direct demonstration. These are only a few illustrations. Every college teacher can check himself to see the extent to which he is providing some guidance of the student's efforts to acquire the new understanding or skills or attitudes or interests or other objectives sought. The extent to which the student gets needed guidance in carrying on the desired behavior is an index of the effectiveness of the teaching.

A fourth condition for learning is for the learner to have appropriate materials to work on. If he is to learn to solve problems, he has to have problems to attempt to solve; if he is to gain skills, he must have tasks which give him opportunity to practice these skills; if he is to gain appreciation, he must have materials that he can hear, see, or respond to in other appreciative ways. When students have only the textbook and the classroom lectures, they do not have enough of the stuff for study—that is, the problems, the exercises, and the other materials to think about, work on, and practice on to provide the necessary learning experiences. Hence, another index of effective teaching is the extent to which materials are provided students that give them the opportunity to practice the kind of behavior the teacher is seeking to help them acquire.

A fifth condition for effective learning is for the learner to have time to carry on the behavior, to keep practicing it. This is usually referred to as having study time. Often colleges assume that the student is spending time in study outside the classroom, when observation or an interview will indicate that the student thinks that if he comes to class and spends a half hour or so outside, that is all that is required. A more effective provision of study time is important for a high level of learning to be reached. Studies of college students show that time which is presumed to be available for study is often occupied in commuting, outside work, extracurricular activities, and social activities. Imaginative and realistic ways of providing study time can contribute to teaching's effectiveness.

A sixth essential condition for learning is for the learner to get satisfaction from the desired behavior. As the learner interacts in the various learning situations, the reactions which give him satisfaction are continued; those which do not are dropped. If the learner wants very much to acquire a certain kind of behavior, the actual satisfaction of getting it is sufficient. On the other hand, teachers are in a position to help learners derive satisfaction from desired behavior when this satisfaction does not automatically follow progress in learning. For example, to become competent in a foreign language so that one can read stories or articles in that language takes a long time. In the interim, the teacher may exercise a considerable influence by complimenting the student on his efforts, by helping to get the group's approval of reasonable progress, by providing tests or other means for him to perceive that he is progressing toward his goal. These are only a few of the ways in which the

teacher may increase the effectiveness of learning by helping the students to get satisfaction as they make progress toward the desired goal. This too can become an index of the effectiveness of college teaching.

A seventh essential condition for learning is the opportunity for a good deal of sequential practice of the desired behavior. Sequential practice means that each subsequent practice goes more broadly or more deeply than the previous one. Sheer repetition quickly bores the learner and has little or no further effect. Only as each new practice requires his attention because of new elements in it does it serve adequately as a basis for effective learning. This is important for the student in gaining understanding: it means that concepts and principles are brought in again and again, but each time in new and more complex illustrations, so that the student continually has to think through the way in which these concepts or principles help to explain or to analyze the situation. It is important in the development of the skill for each new practice of the skill to provide opportunities for greater variety or complexity in its use. This is also true in the development of appreciation, for it means that each new work of art should demand something more of perception and provide opportunity for a greater variety and depth of emotional response. It is possible for the individual teacher, or the college as a whole, to examine the sequential nature of the learning experiences provided in various courses or throughout the college program to see the extent to which they capitalize on the opportunity for high-level learning through continuing sequential development.

An eighth condition is for the learner to set high standards of performance for himself. One of his common difficulties in college is that the student may become satisfied with mediocre performance and no longer put forth effort to learn. This is frequently a problem with the more able student. It is often necessary to help the student to acquire standards of performance that for him are high but attainable and to lead him on continually to seek greater excellence. One may ask of any teaching program about the kinds of standards that the students are expected to meet and how far they are relevant to the individual differences among the students in the class. By interviewing students one can find out what sort of standards each one has set for himself and how he knows that these are appropriate for him. One can make an independent estimate as to whether they are high but attainable, or for him relatively low and mediocre. This is one of the criteria of effective teaching.

The ninth condition is related to the eighth: to continue learning beyond the time when a teacher is available, the learner must have means for judging his performance, to be able to tell how well he is doing. Without them his standards are of no utility. Each teacher may ask himself, "Have I helped the students get some means by which they can judge the adequacy of their performance in this field? To what extent are they using this means?"

One purpose of outlining these conditions for effective learning is to suggest that their use as an indirect means of evaluating the effectiveness of teaching is less rigid, more flexible, and more relevant than the use of methods which set up an ideal description of good teaching against which teachers are checked or which arbitrarily define the proportion of lecture, discussions, laboratory demonstration, individual laboratory work, or other devices which should be used to do a good teaching job. It is possible for creative teachers to get effective results by a variety of procedures. But whatever methods they use or however they stimulate reactions, these methods of teaching do serve to provide the essential conditions for learning and may be judged fairly directly by examining the teaching in terms of the extent to which the conditions of learning are provided. Next to the direct appraisal of what students learn, this examination of the conditions of learning is most valid in evaluating teaching.

In checking the extent to which essential conditions of learning are being provided, two devices are frequently useful.

(*Continued at bottom of p. 868*)

Evaluation of Teaching Effectiveness

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The student is our "product" in the manufacturing process of education. The raw material varies, sometimes in an uncontrollable manner. Classroom instruction is the process whereby the product is formed and this phase is of over-all importance. The final product cannot be evaluated except after a number of years, and in most cases the "feed-back" is obtained too late, or not at all. What can be done is to establish procedures to evaluate short term objectives for a particular course at its termination and to estimate the long term result.

The Problem

These remarks are based on several years' experience as chairman of an In-Service Training Committee for all university teachers. The goal of this committee is the improvement of teaching, primarily through the encouragement of a program of self-evaluation. The main difficulty encountered by the committee was motivation of the faculty to take steps toward self-evaluation and self-improvement. Some of the methods used by the committee are listed below.

1. Short articles are inserted periodically in the University staff letter which call attention to certain points which make for a better teacher, or which quote current literature.[1]
2. An "internship" for younger faculty (working with older, capable teachers on common courses) is encouraged.
3. Classroom observation as such is not considered desirable but faculty members are urged to take a course (audit or for credit) from a good instructor.
4. The use of student rating forms by instructors for self-evaluation purposes is encouraged.
5. A booklet [2] is distributed listing briefly the characteristics of an effective teacher, ways to create student interest, and items for self-evaluation. Although directed toward new faculty, it has something for all.
6. "Name" speakers have been brought to the campus to discuss teaching topics. These were disappointing both as to the information presented and the extent of faculty participation.

The question considered here concerns specific ways by which a teacher may find out about his own effectiveness. This can only be done by the teacher himself with outside help. It is pertinent to point out that whether a person seeks an evaluation or not, and whether he desires one or not, he is continually being judged by students, associates and administrators, sometimes on a prejudicial basis.

Sources of Information

There are some mechanical devices which permit a look at one's self. A voice recording is usually a real surprise, and will show possible improvements in voice inflection and quality, enunciation, and mannerisms.

One person, who has spent much time

[1] R. M. Sutton, "Reflections on Teaching I Have Seen," JOURNAL, Vol. 49, No. 10 (April, 1959), pp. 957–960. Gilbert Highet, *The Art of Teaching*, New York: Vintage Books, 1958. *Improvement of University and College Teaching*, Corvallis: Oregon State College, published quarterly since 1952.

[2] *Useful Information for New Faculty*, Moscow: University of Idaho Dept. of Publications, 1957. Includes reading reference list.

making a series of movies for classroom use (in chemistry), recently remarked that everyone should have a chance to see himself "perform" on film. This person's experience (as evidenced by the films) showed marked improvement with successive lectures produced. The need for good platform deportment need not be elaborated upon, but this is an important factor in the communication process.

Some of the activities listed above had the purpose of getting the teacher to reflect on his own effectiveness to secure a considered opinion of himself. This is the only way the evaluation can really be made, but the teacher needs help from sources outside himself. These include his colleagues, his "supervisors" and his students. Some will deny this, but it appears that student comment, favorable or not, forms the basis for many evaluations of teaching effectiveness.

There has been argument as to whether or not students should evaluate either a teacher or a course, or whether they should have any opinion at all. However, it would appear that there is little choice in the matter, for two reasons:

1. In practice the student is a source of much information.
2. Student attitude is an important psychological factor in the learning process.

Student attitude toward his teacher, and toward the course, is a critical factor in the learning he will experience from that course. This is his motivation (other than the fact that he has to obtain a passing grade). This factor is frequently overlooked by the university teacher although motivation is a primary consideration in teaching in the grades and high school. A "take it or leave it" attitude on the part of the college instructor is not uncommon, and is deplorable in a situation where inspiration would make the instructor's goals (and his reason for being in the classroom) more readily attainable.

How to Evaluate

Many factors contribute to good teaching—knowledge of subject, classroom manner, contributory factors of experience, research and publications, and other professional activities. Specific answers are wanted to the questions, "Am I an effective teacher?" and "How can I improve my teaching?"

It is imperative to go directly to the sources instead of waiting for information to drift back in an unpredictable and sometimes non-constructive manner. Student rating forms provide the most direct answers to questions of teaching performance. The questions can be many and varied and are designed to tell the instructor what his reputation is, what areas are good and which can be improved.

Purdue University has made a detailed and long term study of the use of rating scales for instruction which appears to provide a valid picture of the teacher as the student sees him. Sample forms, instructions and literature are available.[3] Oregon State College has a "Learning Appraisal Form" for the student to evaluate his own progress, and a "Teaching Appraisal Form" for student rating of instructors. The latter is prefaced by a statement on the excellent teacher.

To give emphasis to the validity of student appraisals, and to counter arguments of student immaturity, one publication states—"from a study of the ratings of the same instructors made by on-campus students and alumni of ten years standing, (we) conclude that alumni and students tend to agree substantially on their ratings of these instructors." Another source cautions against possible misinterpretation by some instructors, who lack a standard of comparison, which might lead to a psychological block. Discussion of ratings with colleagues would minimize this possibility and would give perspective.

An inquiry was made of presidents, or other administrative officials, at about ten universities and colleges varying from large to small institutions both public and private. The inquiry concerned

[3] *Manual of Instructions for the Purdue Rating Scale for Instruction*, Lafayette, Indiana: Purdue University Personnel Evaluation Research Service. Includes a bibliography.

methods used for evaluating performance of teachers, and was not limited to self-evaluation of classroom success. Some schools relied solely on opinion of the dean and department chairman for estimating teaching performance (as well as for promotion and salary increases). Others employed outside evaluation agencies which submitted detailed rating forms to students and staff. Most schools which used student ratings limited the information to the instructor and the ratings were not seen by any administrator. Some faculties appeared to fear possible administrative abuse, and some administrators wished to rely heavily on colleague opinion. Some school officials felt the need for a more definite procedure for rating teachers (and asked for any information developed) but none had arrived at a satisfactory procedure for doing this.

It is urged that deans and department heads develop detailed performance evaluation sheets (different from student rating forms) for use in discussions with their staff. Such evaluations, made at regular intervals, would minimize embarassment and make for good reception by the staff members. These forms should indicate good points and areas for improvement and need not be part of the permanent file. Student comment from any source, direct or indirect, could be considered at this time without reluctance on the part of either party. Any type of rating must be discussed with the individual concerned if it is to be constructive.

Summary

1. The best approach for self-evaluation is probably to ask directly for opinions from students and colleagues. This can result in a better student attitude and a better learning situation, and in course improvement and self-improvement.

2. The use of rating forms can provide useful information for performance evaluation. Student ratings can give valid information; ratings by associates can provide a mutually profitable basis of discussion.

3. The use of ratings forms would be justified if these served no other purpose than to stimulate periodic thinking about course content and teaching methods.

THE EVALUATION OF TEACHING

(*Continued from p. 865*)

If the individual teacher is doing his own check he will find the use of a tape recorder in his classroom helpful. After he becomes accustomed to recording class sessions, he and the students will not find recording inhibiting or artificial. Playing back the tapes in his own study gives him a better chance for checking on some of the conditions for learning than is possible by depending solely on his memory.

Where more than one faculty member is interested in evaluating teaching a plan for visiting each other's classes is helpful. Using a list of conditions of learning as an observation checklist, the visiting instructor obtains information useful to talk over with the one being visited, and out of these observations and discussions often develop new and interesting ideas for trial.

Transfers to Schools or Colleges of Engineering 1951, 1952, 1953, and 1959

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This article presents the results of the fourth study of transfers to schools or colleges of engineering. Earlier studies were conducted during the years 1951, 1952, and 1953 under the joint auspices of the American Society for Engineering Education and the U. S. Office of Education. In these surveys the engineering colleges were asked to report the number of students "now classified" as first, second, third, or fourth year students who in the fall of the year in question entered the engineering college by transfer (a) from curriculums leading to engineering degrees, and (b) from curriculums not leading to engineering degrees. The number of such students reported for each class was converted for each institution to a percentage of the total enrollment in that class. These percentages, rather than the actual numbers involved, were used in the preparation of tables contained in the three original reports and in Circular No. 397, dated April 1954, which summarized the three reports. Circular 397 is out of print, but its data on transfers from non-engineering curriculums are included in this circular.

The current survey was conducted because of the belief that there had been a material expansion in the numbers of transfer students since 1953, and that this expansion might account for an appreciable fraction of the decline in engineering freshman enrollment which has taken place during the last 2 years. This feeling was shared by many of the deans of engineering colleges, and at about the time the decision was made to conduct the survey a formal request was received by the Office from the General Council of the American Society for Engineering Education asking that the earlier study be reactivated.

For the purposes of this study is was considered that the transfers from one engineering college to another were unimportant, since they do not change the number of students enrolled in engineering curriculums. Hence, while to a particular institution they may constitute a serious problem, from the national manpower aspect they are considered to be immaterial.

The current questionnaire therefore covered transfers to engineering colleges in the fall of 1959, but only from non-engineering curriculums. Instructions stated that the students reported "should include transfers from liberal arts colleges (in your own or another institution), junior colleges, community colleges, technical institutes, etc., but should not include transfers from degree-granting engineering colleges."

The questionnaires were mailed to the deans of engineering at the same time that blanks for the engineering enrollment report were sent to the registrars. As in previous years, no follow-up was made.

Usable replies were received from 160 engineering colleges, which represent 69.2% of the engineering schools in the United States. The responding institutions in the fall of 1959 enrolled 78.7% of all first-year engineering students, 74.6% of all second-year engineering students, 76.8% of all third-year engineering students, 74.6% of all fourth-year engineering students, and 76.4% of engineering students in the four classes combined. This indicates that the respondents include a higher percentage of

Statistical tabulations and computations by Leah W. Ramsey, Assistant Supervisor, Statistical Services Section. This material has also been published as Office of Education Circular OE-54005.

TABLE 1
ANALYSIS OF RESPONDENTS

Item	1951	1952	1953	1959
Number of engineering colleges to which questionnaires were sent	192	193	210	231
Number of usable replies received	156	163	185	160
Percentage of response	81	85	88	69
Engineering students in first, second, third, and fourth years of respondent institutions as percentage of such students in all U. S. engineering colleges	84	73	95	76

large engineering schools than of small ones. They therefore should not be considered as constituting a scientific sample, but it is believed that the group of institutions is sufficiently representative to give a good indication of general trends.

Table 1 shows comparative analyses of the groups of institutions reported in this survey and those in previous years.

As in the earlier studies, the number of transfer students reported for each class in an institution was converted into a percentage of the total enrollment in that class as reported by the institution in the regular fall engineering enrollment report. These percentages, rather than the actual numbers involved, were used in the preparation of Tables 2 and 3. In these tables the data for 1951, 1952, and 1953 are taken directly from similar tables in the earlier reports.

Table 2 shows for the years 1951, 1952, 1953, and 1959 the maximum percentage of each class reported by any one institution as having been admitted by transfer from a non-negineering curriculum, the weighted average of the percentages so admitted, the median percentage, and the minimum percentage. The last figure is zero for all class levels in every year.

It is evident even from a cursory examination of this table that there is a wide range among institutions in the proportions of their students who have been admitted by transfer, especially during the first 3 years. The large differences between averages and medians are due

TABLE 2
PERCENTAGE OF STUDENTS TRANSFERRING TO ENGINEERING COLLEGES FROM NON-ENGINEERING CURRICULUMS BY CLASS LEVEL, FALL OF 1951, 1952, 1953, AND 1959

Item	Year	Class Level			
		1st Year	2nd Year	3rd Year	4th Year
(1)	(2)	(3)	(4)	(5)	(6)
Maximum	1951	29.7	46.7	41.7	10.7
	1952	23.6	31.7	30.8	6.3
	1953	50.0	50.0	56.2	34.3
	1959	88.0	100.0	66.0	91.3
Weighted average	1951	3.7	5.8	3.8	0.3
	1952	3.4	6.0	3.7	0.4
	1953	2.8	4.0	3.3	0.5
	1959	5.0	8.5	7.5	1.5
Median	1951	2.1	4.0	0.9	0.0
	1952	1.8	3.8	0.7	0.0
	1953	1.0	2.2	0.0	0.0
	1959	2.9	5.6	3.3	0.0
Minimum	All years	0.0	0.0	0.0	0.0

TABLE 3

PERCENTAGE DISTRIBUTION OF ENGINEERING COLLEGES ACCORDING TO THE PERCENTAGE OF TRANSFER STUDENTS FROM NON-ENGINEERING CURRICULUMS BY CLASS LEVEL, FALL OF 1951, 1952, 1953, AND 1959

Transfers as Per Cent of Class	Year	Percentage of Colleges			
		1st Year	2nd Year	3rd Year	4th Year
(1)		(3)	(4)	(5)	(6)
0	1951	34.7	26.3	43.6	84.5
	1952	31.3	24.5	48.5	82.8
	1953	42.2	35.2	54.2	81.7
	1959	23.5	16.7	26.0	69.7
0.1 to 4.9	1951	39.6	30.1	33.3	14.1
	1952	39.2	30.1	28.3	14.7
	1953	37.3	34.5	26.3	13.5
	1959	45.1	30.2	36.4	22.2
5.0 to 9.9	1951	14.2	26.9	10.9	0.7
	1952	17.2	24.5	9.8	2.5
	1953	13.5	17.3	10.8	1.6
	1959	18.5	24.7	19.1	3.1
10.0 to 19.9	1951	8.3	9.6	8.4	0.7
	1952	10.5	13.6	11.6	0.0
	1953	6.0	10.3	4.9	2.1
	1959	8.6	20.4	10.5	2.5
20 or more	1951	3.2	7.1	3.8	0.0
	1952	1.8	7.3	1.8	0.0
	1953	1.0	2.7	3.8	1.1
	1959	4.3	8.0	8.0	2.5

to the fact that in a very small number of institutions the percentages of transfer students are far higher than the average for the group.

The figures quoted as maximum percentages apply in every instance to one institution, and in practically all categories there is a large drop between this institution and the next larger.

Table 3 gives distributions of institutions according to the percentages of their various classes who were admitted by transfer from non-engineering curriculums during the years listed. Columns 3 to 6, inclusive, show for each year the percentage of institutions which admitted the percentage of transfer students indicated in column 1. For example, in 1959, 45.1% of the institutions admitted between 0.1% and 4.9% of their first-year students by transfer from non-engineering curriculums. This represents an increase of 7.8% over the corresponding figure for 1953, during which year 37.3% of the institutions admitted this percentage of first-year students by transfer.

The data contained in Tables 2 and 3 demonstrate without question that there has been a considerable increase in the numbers and percentages of students admitted to engineering colleges by transfer from non-engineering curriculums. At each class level there is a decided drop in the number of institutions which admitted no such students, and with one small exception there are increases in all of the percentages for the various groups covered in Table 3. There is also at each class level a large increase in the maximum percentage admitted, in the weighted average, and in the median percentage. It is quite apparent, therefore, that the problem of the transfer student is growing rapidly in seriousness to the engineering colleges.

As to the relationship between the increases in transfer students and the decline in engineering freshman enrollments, it is unfortunate that this series of studies was discontinued during the years between 1953 and 1959, since it is impossible to get a direct comparison between the figures for 1959 and the corresponding ones for 1958 and 1957.

However, a comparison of the 1959 figures with those for earlier years indicates very clearly that there is such a relationship, and that the increase in transfer students has been a contributing factor in the decline in freshman engineering enrollments. The 5% (weighted average) of first-year students admitted by transfer in the fall of 1959 represent students who were enrolled in a non-engineering curriculum for one or two semesters, and who then transferred to the engineering college but did not receive sufficient credit to be classified as sophomores. Therefore, from the standpoint of engineering these represent students who postponed their entrance to an engineering college for one year. In other words, these students could have entered the engineering college in the fall of 1958, but for one reason or another chose not to do so.

Similarly, the 8.5% of second-year students who were admitted by transfer in the fall of 1959 represent students who have been enrolled in a non-engineering curriculum for 2 years and who, therefore, might have entered engineering school in 1957 and might now be third-year students. From the standpoint of engineering education these students also postponed their college entrance for a year.

Students have been transferring from non-engineering curriculums to engineering colleges for many years, and if their numbers remained constant the "loss" of engineering freshmen in a given year would be offset by the "gain" on transfers from the preceding year, resulting in no net change. But when the number of transfer students increases in one year over the preceding year, the increment results in a corresponding decline in engineering freshmen the following year. Similarly, a decline in the number of transfer students in one year will result in an increase in engineering freshmen the following year, as is illustrated by the increases in engineering freshmen which followed the declining percentages of transfer students shown in Table 2 for 1952 and 1953.

It does not seem worth-while to carry out any elaborate mathematical computation in an attempt to arrive at an exact fraction of the engineering freshman enrollment drop which can be attributed to the increase in transfer students, but it is obvious that there is a direct connection.

The following is an example of how such a computation might be made if data on transfers in 1958 were available. Assuming the sample of institutions to be a valid one, the change in the weighted average from 1958 to 1959 applied to total engineering freshmen in 1959 would give a figure for the total number of transfers, which could then be converted to a percentage of the total increase or decrease of engineering freshmen.

The percentage of transfers at the first-year level in 1958 in all probability lies somewhere between two extreme values, determined by (a) assuming that the increase from 1953 to 1959 took place uniformly throughout the 6 years, or (b) assuming that the entire change took place between 1958 and 1959. Using the first assumption, it is estimated that the increase in transfer students from 1958 to 1959 accounts for about 11½% of the decrease in freshman enrollment. Using the second assumption it would account for 61½% of the decrease. Similarly, the increase in second year transfers would account for somewhere between 6½% and 30½% of the decline in sophomore enrollment.

These extremely wide ranges in possible values furnish a good example of the importance of continuity in statistical studies in any field of education. If the study of transfers had been continued through the years between 1953 and 1959 the resulting data would make possible a much more reliable measure of the relationship between transfer students and freshman enrollments.

It might be pointed out that there has also been a growth in the number of "3–2" programs, in which engineering colleges cooperate with liberal arts colleges in the offering of 5-year curriculums leading to degrees both in liberal arts and engineering. This development also in-

creases the number of students transferring from non-engineering curriculums to engineering colleges, principally at the third-year level.

When it is remembered that 83% of the engineering colleges which responded to the 1959 questionnaire admitted second-year students by transfer from non-engineering curriculums, that 74% admitted first-year students by this method, 74% admitted third-year students, and 30% admitted fourth-year students, it becomes evident that the problem of transfer students is important in a significant proportion of the engineering colleges of the country.

PROGRAM—SIXTH UPADI CONVENTION

Buenos Aires—September 18–22, 1960

Sunday Sept. 18th	Fiesta at an estancia outside Buenos Aires for Congress on Engineering Education and UPADI Convention
Monday Sept. 19th	9:00—Registration at Engineering Society Building 10:30—Plenary Session under President of Board of Directors Designation of Credentials Committee Report of Credentials Committee Report for period September 1958 to July 1960 as required by Art. 13 (see below) of the Convention Rules Ten minute intermission Election and installation of Convention officers Designation of Honorary Presidents Designation of Resolutions Committees: Administration, Legislation, Relations, Technical Matters, Budget, Special committees Round tables—Article 18 (see below) of Convention Rules 3:00—Meeting of Committees 8:00—Opening Session of 6th Convention Speech of President of Board of Directors Remarks by delegates from North America, Central America and South America Speech of President of Argentine Engineering Society 10:00—Reception by Argentine Engineering Society
Tuesday Sept. 20th	9–12—Commitee meetings 3–6 —Round Tables 6:00—Meeting of Board of Directors of UPADI Fund 8:00—Meeting of UPADI Board of Directors
Wednesday Sept. 21st	9:00 AM to 8:00 PM: Visit to San Nicolas industrial zone for delegates whose committee work is finished 9–12—Committee meetings 4–6 —Committee meetings
Thursday Sept. 22nd	10:00—Meeting of Coordinating Committee 4:00—Plenary Session Voting on resolutions and recommendations Presentation of conclusions of Round Tables Election of Board members—Canada, Mexico and Paraquay go off the Board on 31 December 1960 Selection of seat of the Board for 1961–1963 Selection of Convention site for 1962 6:00—Closing Session Resume of the Resolutions by the Secretaries Remarks by heads of delegations Speech of the Convention President 10:00—Reception

Ladies' Program:
Sunday 18—Fiesta
Monday 19—Reception
Tuesday 20—Tea and Fashion Show
Wednesday 21—Tour of city
Thursday 22—Reception

The Technical Graduate in Industry

HENRY B. du PONT

Each year, young men and women from our technical schools grip their diplomas firmly and embark upon the cruise which tests the quality of their training and their own capacity to achieve. Today, a new factor figures in the accounting—one which a generation ago gave only a hint of its present importance. Most of the technically trained today, whether they enter industry, the military, academic life, or some other activity, will carry on their professional life as members of an organized team, for science and technology today are very largely organizational activities. Personal success or failure and the success or failure of the American technical effort will rest, therefore, upon how the technical graduate responds to the challenge of the organizational environment.

There has been considerable confusion about group effort. The place of the large-scale organization in society is subjected to criticism from time to time, and no one would argue that improvements should not be sought or that abuses should not be corrected where they exist. Yet the criticism frequently betrays basic misunderstanding both of the nature and the function of the organization.

Though many scientists today work as part of a group, individualism is no less important than it ever was, for all science has its genesis in human imagination, whether alone or as a part of a cooperative effort. But to translate the product of man's ingenuity from an idea to a useful reality requires not one human imagination, but many; not one set of facts, but many; aided by all the skills and resources that can be enlisted.

Taken from a speech before ASEE, Wilmington, Delaware, May 14, 1960. Recommended by the RWI Division.

The instrument created for the purpose in this country is the corporation which exists for the purpose of performing those tasks which have become too complex and too involved in scope and scale to be handled in any less formidable way. The corporation is by no means a substitute for human ingenuity or personal inspiration. Its function is by no means an alternative to individual achievement. It is, rather, a mechanism through which the individual's contribution can be multiplied many times over and the fruits shaped to public benefit, not by the slender jacknife of the lonely whittler, but by the massive and multisided cutting tools of coordinated effort.

The newcomer to industry or the student looking to an industrial career will, if he is intent upon maximum utilization of his potential, study well the social form represented by the organization. He will come to understand its functions and its needs. As he does so, he will perceive that the strength of the modern organization does not lie in an unbending, inflexible pattern, but in its very diversity of talents, its diversity of viewpoints, and its diversity of individual character, unified and held in balance by a common purpose.

The newcomers to industry are the product of a great deal of devoted work in and by the colleges. The question uppermost in the minds of the educator is, "How well prepared are these young people for the task at hand?"

The answer lies not so much in the field of technical proficiency as in the simple matter of adjustment to the industrial environment. It is here that difficulty sometimes arises, the result very often of mistaken impressions which prevail in many quarters about the nature of industrial organizations.

Much of the criticism hurled at the corporation in recent years is based on the idea that employees are required to

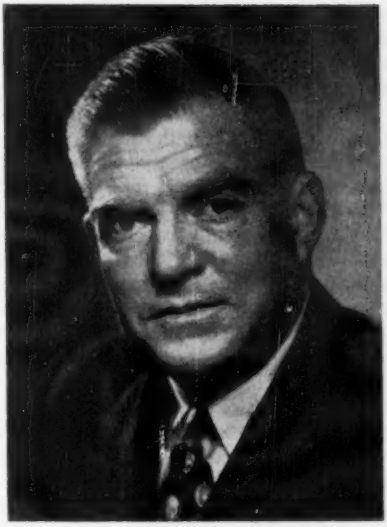
"conform" to some predetermined pattern and must check their personal identities each morning as they might check their hats. Many new employees appear to believe this without question.

Yet, paradoxically, part of the difficulty in adjustment to the business environment after college arises not out of any requirement for conformity, but out of a reluctance to exercise individual initiative. Much of this, I am sure, comes simply because the new employee has the notion that he is expected to be only a cog in a big and complicated wheel.

The transition from the campus to the business world is never easy. In college, there is a certain uniformity, at least in work assignments and schedules—the student is rarely in doubt as to what is required of him. But, in industry, the new employee is often confused and learns only after some discouragements that meaningful work and the opportunity to contribute are seldom automatic and are far more likely to develop out of the individual's own resourcefulness than in any all-inclusive way.

Recently we had occasion to interview a representative group of young engineers on problems they had found most difficult in the early days of employment. The replies indicated considerable confusion about the role of the individual. To a surprising extent, it was evident that the newcomers had underestimated the degree of latitude that would be accorded them and that many had looked toward others to plan and direct their work in detail. Where, either through error or indifference, the individual left the responsibility for his routine to someone else, the result frequently was a series of trivial and routine assignments with its full share of dissatisfactions and frustrations. Those who adapted themselves most readily were those who showed the qualities of self-reliance and self-sufficiency and who recognized that there was no piggyback progress to be made in business or anywhere else.

Most of the respondents felt that their technical training had been largely adequate, but a number noted that they felt a deficiency in the "human relations" es-



HENRY B. DU PONT

sential to advancement in an industrial organization. I am afraid that this can mean only that they brought with them considerable misunderstanding of the corporate environment. The fact is that there is nothing unique about a business organization that makes it differ from organizations of any character and it calls for no more nor less in the way of human relations than the family, the school, the military, or the race itself. The member of a group who is conscientious and courteous in his personal contacts will find people responding in kind. Conversely, there is no reason to believe that disagreeable and unpleasant attitudes are any more likely to win the approval of an associate or a customer than they will warrant the esteem of a team mate, a teacher, or a wife.

Getting along in a business organization, in other words, calls for the same qualities of tact, understanding, and patience which are the requisites of getting along anywhere. The individual with ideas gains support and cooperation through persuasion and through learning to present his views effectively, in business as in any other human society. He cannot expect to upset in a single day the customs and the policies that have

developed over years of experience, yet, if his ideas are sound and his methods of advancing them are well considered, perseverence will produce results.

The history of American industrial progress is strewn with the gravestones of organizations whose managements had become conformist and resisted change. Those that survive have done so because they are continually revitalized by the new blood that they infuse into their veins and by the new ideas that develop in a vigorous and aggressive organization.

Leadership in tomorrow's world will require much long-range study from a background sufficiently knowledgeable to form sound judgments. The role will be assumed neither by those who know a great deal about a very little or a very little about a great deal. It will be discharged only by those whose thinking is broad and uninhibited, those with grasp and understanding, those capable of integrating, consolidating, and reconciling the many diverse and conflicting forces which comprise our society.

Science, after all, is of little use so long as it is isolated within the ivory tower and remains aloof from the needs of man. It is equally sterile if inability to solve our organizational problems confines our science to theoretical limits. Albert Einstein, surely as "pure" a scientist as ever lived, summed up the challenge of the times very well and I leave his words with you in conclusion. "Unless science and technology are pursued in the interest of human betterment," he said, "they remain an indulgence which no nation can afford."

Henry Belin du Pont, a vice president, director and member of the Executive Committee of E. I. du Pont de Nemours & Company, was born in Wilmington, Delaware, on July 23, 1898, the son of Henry Belin and Eleuthera Bradford du Pont.

A great, great-grandson of E. I. du Pont de Nemours, founder of the company, M du Pont joined the company as assista treasurer in 1928, after five years of busine experience elsewhere. The following ye he was transferred to engineering work an has since been associated prominently wi engineering research and development. H was for some years head of the Technic Division of the Engineering Departmen In 1934, Mr. du Pont was elected a membe of the Board of Directors, and in 1939, vice president and member of the Executi Committee. He is president and a directo of Christiana Securities Company and a Di rector of the Wilmington Trust Company.

Mr. du Pont has long been actively in terested in engineering education. He ha spoken before many educators' groups a the subject with particular emphasis on th role of liberal arts in preparing for caree in industrial technology.

Following preparatory work at Pomfre School in Connecticut, Mr. du Pont entere Yale in 1916. He majored in history, an was graduated with the degree of A.B. i 1920. He did three years of postgraduat work in mechanical and aeronautical engineering at Massachusetts Institute of Technology, and received the degree of B.S. i 1923. He was awarded the honorary de gree of Doctor of Science by LaSalle Col lege, Philadelphia, in 1953.

Mr. du Pont is president of the Board o Education of Alexis I. du Pont School president of the Board of Trustees of the Longwood Foundation; a trustee of the University of Delaware, the Episcopal Church School Foundation in Delaware, and Pomfret School, Pomfret, Connecticut. He is a member of the Board of Managers of Wilmington Institute Free Library. He is also a member and a former senior warden of Christ Protestant Episcopal Church, Greenville, Del.

From November 1938 to December 1959, Mr. du Pont was a member of the board of General Motors Corporation, with which he was associated as a research engineer on internal combustion engines for a few years prior to joining the Du Pont Company. He has been a director of Remington Arms Company, a Du Pont subsidiary, since 1946, and is a director of North American Aviation, Inc.

New Horizons for Experimental Investigation in the Mechanical Engineering Curricula

GORDON B. CARSON

Vice President and Professor of Industrial Engineering
Ohio State University

The engineering laboratory plays a vital role in the training for professional leadership. Rapid changes occurring in science and technology are now being reflected in major engineering curricular redesign. The most difficult aspect of curricular planning and execution is that which deals with laboratory education.

The conviction that a very strong effort must be directed to solving this problem on a nation-wide basis stimulated the formation of an unofficial ad hoc committee for mechanical engineering experimental laboratory instruction.

We live in an engineering world in which static conditions seldom prevail. And the design function of the mechanical engineer is far broader than the "design of machine elements" concept which formerly guided the thinking of many educators.

Further, mathematical analysis, a fine and necessary procedure in all phases of engineering, must be supplemented by experimental processes if the engineer is to extrapolate safely from the mathematical model to the actual conditions which prevail.

These factors stimulated the formation of an unofficial ad hoc committee originally made up of Richard G. Folsom, President, Rensselaer Polytechnic Institute; John A. Hrones, Vice President, Case Institute of Technology; Norman A. Parker, Chairman, Department of Mechanical Engineering, University of Illinois; and Gordon B. Carson, Vice President, The Ohio State University, acting chairman of the group.

An unscheduled meeting took place at the ASME meeting in Atlantic City in November, 1959. This meeting was exceptionally well attended, and those who were present urged the continuation of the Committee in expanded form. ACTION, not words, was the charge. "Obsolete cast iron museums must go," was the theme.

Accordingly, the National Science Foundation, with Doctors Bowen C. Dees, Assistant Director for Scientific Personnel and Education; Arthur Roe, Head, Course Content Improvement Section; Richard E. Paulson, Assistant Project Director, Course Content Improvement Section; and Ralph H. Long, Jr., Engineering Sciences, spearheading the move, called a meeting in Washington, D. C., on January 22, 1960, to plan the next step.

At this meeting the steering committee was expanded to include Professors James B. Hartman, Chairman, Department of Mechanical Engineering, Lehigh University; John F. Lee, Broughton Professor of Mechanical Engineering and Head, North Carolina State College; and Newman A. Hall, Chairman, Department of Mechanical Engineering, Yale University.

With the advice of the steering committee, the National Science Foundation sponsored a two-day conference in Washington, D. C., on March 25 and 26, 1960. This conference, attended by 37 invited members of mechanical engineering faculties, included examination of several approaches to the solution of the problem of the experimental laboratory in the mechanical engineering curriculum.

Two projects are now supported by the National Science Foundation, under the direction of Professor John F. Lee at North Carolina State College and Professor James B. Hartman at Lehigh University. These are respectively, "A study of the Course Content in Experimental Mechanical Engineering," and "The Development of Educational Aids in Mechanical Engineering." They represent

two approaches toward a solution to the experimental laboratory problem, coordinated by a common advisory committee selected by the project directors to provide policy guidance and help in planning.

The National Science Foundation Washington Conference on the Mechanical Engineering Laboratory arrived at several conclusions which will be explored further. Among these are the following:

- Design must be tackled on a systems analysis basis in the advanced stages.
- Laboratory must become the experimental arm of regular courses taught by regular staff instead of a separate curricular entity, with a "laboratory staff."
- Routine testing experiments must be replaced with fewer experiments of more comprehensive nature and greater challenge, resulting in a formal professional type of report.
- All forms of experimental endeavor must be used . . . demonstration . . . participation . . . individual student initiative in designing and conducting an experiment. . . .
- Statistical validity in experimental processes must be covered thoroughly.
- Analogues of some phenomena appear to be the most desirable methods for experimental investigation.
- Old laboratory specialties may have to be abandoned for a more fundamental and yet broader consideration of phenomena involved in a given experimental investigation.

The conference passed these resolutions unanimously:

"That the steering committee under the chairmanship of Gordon B. Carson be continued, with the privilege of calling further conferences, and that consideration be given to the employment of a full-time executive secretary to implement progress toward the complete integration of the experimental laboratory into the regular courses in mechanical engineering."

"That foundations be encouraged to support curricular introspection, such as that engaged in at the University of California, Los Angeles, in the individual departments of mechanical engineering throughout the country."

The steering committee, enlarged by the addition of Professor Kenneth Wadleigh of the Massachusetts Institute of Technology, will now take the following action:

1. Provide news releases covering work of the committee to date.
2. Establish a procedure for disseminating information on projects and action taken to improve the Mechanical Engineering Experimental Laboratory program.
3. Investigate and stimulate the provision of Foundation support for a continued program of research and development in the Mechanical Engineering curriculum.
4. Organize a summer work conference on the Mechanical Engineering Experimental Laboratory in 1961 at which time the developments of the intervening period will be delineated, further solutions proposed, and a framework of action presented to all conferees.

COMPUTER APPLICATIONS SYMPOSIUM

The 1960 Computer Applications Symposium sponsored by Armour Research Foundation of Illinois Institute of Technology will be held October 26 and 27 at the Morrison Hotel, Chicago.

The conference will stress user experience on the frontiers of computer applications and programming techniques. Invited papers will represent business and management, and engineering and scientific applications.

Inquiries concerning the conference should be addressed to Andrew Ungar, conference program chairman, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

A Study of the Properties of Engineering Materials

PAMELA G. DUNSMUIR
AND J. S. WIGNALL

Department of Science and Mathematics, College of Engineering Technology, Rugby, England

A teaching course on the properties of engineering materials has been under development for the past few years at the Rugby College of Engineering Technology. It covers similar ground to the type of course recommended by the Follow-Up Committee on Evaluation of Engineering Education of the ASEE in their report published in the JOURNAL (Vol. 49, p. 72, 1958).

It may be of interest to the members of the ASEE to have an outline of the scheme of work at Rugby. To make the standard of the course clear an introductory paragraph is necessary.

Engineering students enter the College at the age of eighteen with Advanced Level successes in mathematics and physics in the General Certificate of Education Examinations. A success of at least Ordinary Level in Chemistry is required also. For a period of five years, half of each year is then spent at the College, the other half-year being spent in industry with the firm which employs the students as engineering apprentices. This arrangement is known in Britain as a "sandwich" type of course.

These courses of the Rugby College of Engineering Technology are recognized by the National Council for Technological Awards as leading to its Diploma in Technology (Engineering), which is of equivalent standing to an engineering degree of a British University.

Engineering Materials Course

During the first four years of sandwich courses in electrical and mechanical engineering the curriculum includes the subject, "A Study of the Properties of Engineering Materials." Approximately one-fifth of the teaching time is devoted to it.

The arguments leading us to establish a special course of study of the science of engineering materials as a part of engineering training are as follows:

During the past few decades a wide scientific knowledge has been reached concerning the physical properties of all kinds of engineering materials. To give a few instances, the strength and mechanical properties of metals are largely explicable in terms of crystal structure and dislocations. The behaviour of magnetic materials has been elucidated in terms of their constituent electrons. The theory of semi-conductors, insulators and conducting materials is based on electron energies and explains the distinction between them. The theory of polymerization and its application to plastics is well advanced.

Again, developments in engineering techniques require materials of improved performance, obtained either by using specially developed new substances or else by enhancing the properties of existing materials in some way. Examples are: higher compression ratios in internal combustion engines require new fuels, so do rockets; machines working at ever greater extremes of temperature and pressure require new lubricants; the endeavour to carry out processes and techniques at high temperatures has brought new ceramics and refractory materials into prominence; the search for magnetic materials which can be used at high frequencies has led to the use of ferrites, and so the list could be continued with light structural materials, corrosion resistant materials, *et cetera.*

In addition to well established manufacturing processes, a number of new processes and techniques require special study by engineers. Instances are zone refining, single crystal growing, polymerization, high vacuum work and sintering and pressing techniques. Further-

more, the ultimate depletion of natural mineral resources has to be faced and alternative materials sought for all kinds of uses.

The basis of a study of materials must be the fundamental science associated with atomic, electronic, crystal and molecular configurations. In these terms the theories concerning the properties of materials are now sufficiently consolidated to form a sound basis for a scientific course of study. Not only this, but fundamental scientific knowledge is leading to new industries of tremendous importance. Examples are nuclear energy and the industries connected with new fibres, plastics and new magnetic and electrical materials. No engineer can afford to be without a basic knowledge of modern science, particularly since, in any large project, he is likely to be working with chemists, metallurgists and physicists brought up in the new fields of fundamental knowledge. It is essential that he should be able to talk their language.

Our scheme then starts with basic science studies. Rather than give syllabuses we present a summary of our scheme of work.

Scheme of Work for Science Department, College of Engineering Technology, Rugby

A Study of the Properties of Engineering Materials

1. *Fundamental Science.* Ionization of gases, leading to evidence for the electron. Structure of the atom. Bohr theory. Electronic configurations, ionization and excitation potentials. The periodic classification of the elements. Natural radioactivity, the nucleus, the neutron, the proton. Artificial radioactivity, nuclear reactions. Mass energy equivalence. Principle of Einstein. Nuclear fission and nuclear energy.

   Duality wave and corpuscular properties of radiation quanta. Wave properties of particles—experimental evidence. De Broglie's equation. Schrödinger's equation. Interpretation of wave function. Uncertainty principle. Types of bonds. Crystal structures. Miller indices. Important types of crystals and their investigation by x-rays.

   Cooling of molten metals. Application of phase rule considerations to the cooling. Thermal equilibrium diagrams. Phase changes. Important phase changes in metals and other materials. Introduction to organic chemistry. Hydrocarbons. Petroleum. Polymerization. Important groups of compounds such as alcohols, acids and esters, benzene and aromatic hydrocarbons.

   Electrode potentials, pH values. Introduction to corrosion theories. Energy relationships, heats of combustion, entropy and enthalpy.

2. *The Preparation and Properties of Engineering Materials Interpreted in the Light of Fundamental Science.*

   Metals, Elements and Alloys. The electron theory of metals. Zone theory, energy bands and atomic energy levels. Application to cohesion and to the zone theory of alloy phases. The use of x-rays for investigation of structures of metals, of alloy phases and of preferred orientation. Ordered structures. Order-disorder phenomena and transformations.

   Materials Important for their Mechanical Properties. The effect of defects and dislocations. The macroscopic stress/strain curve and its correlation with microscopic changes in the material. Lubricants and lubrication.

   Magnetic Materials. Hard and soft magnetic materials, ferrites. Heusler and other magnetic alloys, dust cores. Theory of dia, para and ferromagnetism. Antiferromagnetism and ferrites. Domains and their behaviour through the hysteresis cycle. Domains in hard and soft materials. The preparation of magnetic materials—grain orientation. The preparation of ferrites. Magnetostrictive materials.

   Materials Important for their Electrical Properties. Semi-conductors. Insulators. Free electron theory of

metals and electrical resistance. Zone and band theories applied to insulators and to intrinsic and extrinsic semi-conductors. Types of semiconducting materials. Thermistors. *Materials used as insulators and dielectrics.* Dipole moments and dielectric loss. Glass, plastics, ceramics, elastomers. Inorganic insulators, old and new. Piezo electricity and ferroelectricity. Luminescence and electro-luminescence. Fluorescence and scintillation. Photo-conduction. Superconductivity.

High Temperature Materials. Structural considerations. Special alloys, metal oxides, carbides, borides, silicides. Ceramics and cermets.

Materials for Nuclear Plants. Principles of nuclear power production. Radioactive tracers and their uses. Moderators and neutron absorption. Special materials for nuclear plants. Steels, alloys, carbon, fluorine compounds, canning materials. Liquid metals. Plastics.

3. *Experiments.*
Fundamental science experiments, and also experiments to illustrate the preparation, properties and limitations of engineering materials of all kinds and to illustrate new processes and techniques.

It can be seen that the fundamental science treated in section (1) is followed by a section in which the ideas are applied and extended to the interpretation of the preparation and properties of important types of engineering materials. For instance, in section (1), electron energy levels for the atom are studied, and also the basic ideas of wave mechanics. In section (2) these ideas are applied to a descriptive account of the band theory and the Brillouin Zone theory of solids, leading to an understanding of intrinsic and also p-type and n-type semi-conductors.

Again in section (1), the properties of x-rays are given and also their application in crystal analysis. In section (2), x-ray metallography is dealt with in some detail, including such topics as the identification of alloy phases, preferred orientation and texture analysis.

Great importance is attached to the third section of the course, which consists of laboratory work. Some of the experiments are designed to illustrate the fundamental science of section (1). Examples are the measurement of the charge and mass of the electron and crystallography experiments. Other experiments are linked to the preparation and properties of the engineering materials which are studied in section (2). For instance, a whole group of experiments deals with magnetism, linking very closely with the theory. The non-magnetic element manganese is suitably alloyed by the student to convert it into a magnetic material, thus confirming the general theory and illuminating the case of the Heusler alloys. Magnetism is continued with a study of the ferrites. Copper or nickel oxide is mixed with ferric oxide and heat treated to make either a copper or nickel ferrite. The preparation of this magnetic material is followed by a further experiment to determine some suitable physical property such as the Curie point.

Similar groups of experiments are being devised for the other types of materials. The building up of experiments of this nature which illustrate the preparation of an important material and the basic science underlying its properties is very fascinating. The requirement that the student should be able to perform the experiment within the few hours of a laboratory period is itself a great challenge. For instance, it is not possible for students to zone-refine germanium or silicon, but the process is illustrated by a zone melting purification of naphthalene coloured by a minute trace of a suitable blue dye. The temperature of the molten zone is only about 100° C. in this case, so that the physical conditions are easy to obtain in the laboratory.

It can be seen that the course on the Properties of Engineering Materials which is being run in Rugby does follow the program recommended in general terms by the ASEE. In both cases the treatment of the properties of materials is based on physics, chemistry and mathe-

matics. The list of concepts given in the ASEE report includes rather more items than we consider appropriate for students who will become either electrical or mechanical engineers. We feel that there is a danger of a course for engineers becoming too diffuse and so the Rugby scheme emphasizes materials important for their mechanical, electrical and magnetic properties. At the same time, such topics as corrosion, lubrication, fuels and high temperature and nuclear plant materials are not neglected.

Materials Specialists

The importance of materials in modern industry is now so great that, in our opinion, the time has come to found a course devoted entirely to the study, both fundamental and practical, of materials. This we are endeavouring to do, in addition to running the materials course for engineers outlined above. The aim is to produce a scientist who is not a chemist, metallurgist, physicist or engineer, but a specialist in the science of materials. Such a man will be able to work along with all his scientific colleagues and to interpret the work of each to the others. By his wide knowledge of materials he will see quickly the implications which work done in one field has for work being done in another. He will, we imagine, find a place both in research and in development. The engineer, particularly one whose science training has been along the lines of the scheme described above, will be able to consult this colleague with the feeling, mutual to both, that they can understand one another and work together.

The future will decide whether this specialist scheme can be developed, but at least the work we are now doing explains the interest we feel in the ideas that are coming out in the JOURNAL with respect to the part that the study of the science of materials can play in engineering education.

HIGH SPEED DIGITAL COMPUTER AT IOWA STATE

Iowa State University has began operation of its new high speed digital computer, known as CYCLONE and constructed by university personnel. CYCLONE will be used, along with an IBM 650 machine which has been in operation for more than two years, in teaching and research as well as service in the computing and data processing center of the university.

Iowa State decided to build—rather than buy or rent—its new computer, largely because it wished to establish on campus a highly competent engineering group engaged in electronic research, computer design and component development.

Iowa State engineers have been gaining experience in these areas in the construction process and have been able to incorporate new and up-to-the-minute advances in their machine.

Construction was made possible through the unstinted cooperation of the University of Illinois. Iowa State was offered the complete blueprints for ILLIAC, a machine which Illinois had constructed, and Iowa State personnel spent several months on the Illinois campus acquainting themselves with ILLIAC.

Michigan State University and the University of Sydney, Australia, have also completed machines modelled on ILLIAC, and four institutions are sharing program libraries.

The first stage of construction called for the building of the main computer with its rapid computational speed, but relatively small memory. The second stage involves a construction of a memory 16 times as large. CYCLONE now has an electrostatic random access memory which can store 1,024 words of coded information. The expanded memory will be a random-access magnetic core system with a total capacity of 16,384 words. National Science Foundation has granted Iowa State $100,000 for this project which will take between one and two more years.

Welding Education in the Engineering Curricula

R. DAVID THOMAS, JR.

President,
Arcos Corporation,
1500 South 50th Street,
Philadelphia 43, Pennsylvania

Industry has been all to prone to blame our university faculties for the shortcomings of the engineering graduates without offering constructive suggestions for meetings its needs. All too frequently the pressure from industry is to expand the training in the manufacturing processes. My experience has been primarily in the welding of metals, and it is from this experience that I offer a concrete suggestion as to how this particular manufacturing process might be incorporated in engineering curricula.

The need for welding knowledge in the engineering curricula has become so urgent because of its growing importance to all of the engineering fields. During the past decade, almost every engineering society has devoted a portion of its convention programs to some aspects of welding.

The core of my suggestion is based upon a quotation of Alfred North Whitehead, used in the 1958 presidential address of Dr. Frederick C. Lindvall before ASEE: "A well-planned University course is a study of the widesweep of generality. I do not mean that it should be abstract in the sense of divorce from concrete fact, but that concrete fact should be studied as illustrating the scope of general ideas." If the trend among our engineering educators is for increased emphasis on basic sciences and in cultural and humanistic studies and if to do so causes the elimination of manufacturing process training, the solution might well be to follow Dr. Whitehead's suggestion of inserting manufacturing processes as illustrative facts in the more general curriculum.

Welding is particularly adaptable to this proposal. For example, an electric arc traveling at a given rate of speed might be used in a mathematics course as a problem in determining rates of heat flow at various distances from this traveling source of heat. Physics classes, studying forces deflecting simple beams, should be given problems illustrating the reduction in deflection when the same force is applied to beams having welded flanges. The helium or argon shielded arc welding process should be described in a chemistry course, illustrating the application of the inert gases. These are but a few of the types of examples that one can visualize inserting in basic science courses.

The examples are numerous, when considering the applied engineering courses. A course in the properties of metals must certainly incorporate the characteristics of welds and the heat-affected zones adjacent to welds. Machine and structural design courses cannot avoid instruction in welded designs. All too frequently riveted and bolted connections occupy a major portion of such a course, when in reality, the welded connections are becoming the dominant joining method for many structures.

The great need of industry now is to make certain that every engineer has an adequate exposure to the subject of welding, because he is sure to face welding in some manner in his professional career. Fortunately, there are a number of institutions who have taken cognizance of this need. Welding engineering has re-

Presented at the ASEE Annual Meeting in Pittsburgh, June, 1959. Recommended for publication by the Machine Design and Manufacturing Processes Subdivision of the Mechanical Engineering Division.

cently been recognized by the accreditation authorities as a curriculum at Ohio State University. In describing his five-year curriculum, Professor Roy B. McCauley writes: ". . . this curriculum is a NEW educational experience in engineering where, by the very nature of the process that we pretend to understand, we are forced to take course work in all the manufacturing areas and then can never be content with only fundamentals for our problems are the most important frontiers of other areas."

The trend towards the elimination of courses in manufacturing processes can have a harmful effect in the training of our young engineers. With all due respect to the broad education which our young engineers obtain by increased emphasis in basic sciences and cultural studies, it would be folly to allow these young men to graduate without any exposure to manufacturing processes. To neglect a manufacturing process, such as welding, in a student engineer's training, should be viewed as seriously as if the medical faculties should neglect the teaching of pharmacology to our future doctors. No engineering senior should be granted a diploma without adequate familiarity with our important manufacturing processes. By a careful selection of the principles being used in our manufacturing processes, sprinkled freely throughout the basic sciences and applied engineering courses, the necessary background can be obtained without encroaching on the time needed for other educational pursuits.

Manufacturing Processes Courses

D. C. DRUCKER

Professor, Division of Engineering
Brown University, Providence, Rhode Island

The choice of the appropriate content of an engineering curriculum is a most difficult one. Time is so precious that essentials alone should be included. We must keep in mind that our primary function as engineering teachers is to educate engineers and not to train technicians. Therefore, in addition to humanistic and social studies we all include mathematics, science, and engineering science. Why then are these subjects not enough? It is important that we also introduce our students to:

1) the analysis of complex real situations rather than just to *given* simplified models of the real world;
2) the concept of design and some practice in its use in an environment where basic theory is understood and respected. (This is too often not so in industry);
3) the way of life he will encounter after graduation.

Each of these desirable objectives has a hidden trap. As illustrations of the type of course which is not of enough value under present day pressures there are:

a) an analysis course in which the student is told exactly how to analyze a given set of well-defined problems;
b) a design course in which most of the time is spent following a given specification or group of specifications or codes;
c) any course which primarily tells how to do something not why.

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Perhaps up to this point we all agree in principle, but I would include any course in which the "how" even begins to approach equality with the "why." In other words, a manufacturing processes course of the usual type is undesirable.

This opinion does not represent a prejudice against the subject itself. Manufacturing processes provide excellent illustrations and should be discussed as often as possible. For example, in the study of the plastic behavior of metals (a part of engineering science), metal cutting, extruding, rolling, forging are important topics for analysis. They can provide suitable laboratory experiments as well. In the study of metallurgy and the chemistry and physics of solids, changes occurring during casting, heat treatment, etc., form a fine group of illustrations.

However, in my opinion, it is not at all true that "a thorough training in manufacturing processes is just as basic to the potential industrial, mechanical, electrical, and aeronautical engineer as calculus and physics." [1] If free electives are available, and they should be in every curriculum, a course in mathematical economics is far more valuable than a course which tells how sub-processes are strung together to obtain a complete process.

Manufacturing processes courses, if given, should be science or design courses. They should be so labelled to avoid confusion. Science and Economics of Manufacturing Processes or Design of Manufacturing Processes might be proper. Of necessity, therefore, a manufacturing processes course for credit must be at the junior or senior year level. Earlier courses cannot count on a sufficient science and mathematics background. A reading of college catalogs shows the overwhelming majority to be beginning courses instead. Also, the vast majority of advanced courses are "methods" courses.

Course credit should be given for academic work only. Certainly, during the undergraduate years direct experience in a machine shop, or forge, or foundry, or manufacturing plant is of great value. Plant tours and allied reading also are to be encouraged strongly, but no credit should be given.

In summary, if manufacturing processes courses are to be engineering courses, they must be on the same high level as analysis and design courses and should, in fact, be numbered among them. Extremely few of the many courses now offered to engineers measure up to this standard.

[1] B. N. Niebel, "Manufacturing Processes in Engineering Curricula," JOURNAL, Vol. 49, no. 9, May 1959, p. 797.

A COOPERATIVE PROGRAM FOR UNIVERSITIES

A cooperative development program has been agreed to by Oklahoma City University and MIT in which, for at least one year, five members of the MIT faculty will be loaned to OCU to teach on its faculty. In addition, five members of the staff from OCU will enter MIT for a year's training and refresher courses in the subjects they are teaching. MIT also has set up an Advisory Committee to cooperate with the President and faculty of OCU to revise and upgrade its curriculum. To insure success of the plan OCU is launching a campaign for about 2.5 million dollars for enlargement of faculty, increased salaries, scholarships for outstanding students, and laboratory equipment.

The First Half or the Whole Engineer

A. J. TELLER

Professor and Research Professor, Chemical Engineering
College of Engineering, University of Florida

There has been, in the last decade, a turmoil developing in the engineering colleges of this country—a turmoil related to the establishment of objectives of engineering education.

As a result of the explosive increase in rate of accumulation of knowledge and concepts, engineering is accelerating its emergence from the practice of empiricism toward the conditions wherein its creativity can rest on the firmer foundations of concept. We have not yet, and may never arrive at a state where all the complexities of behavior of systems can be shed of all empiricism, but the cocoon is broken and with it many of the inhibitions placed on the practice of engineering.

As rational engineers, we should grasp the advantages of fundamental concepts in our creative work, still observant of their present limitations as we have been cognizant of the limitations of empiricism. As irrational human beings, we have at times been prone to excesses in our behavior in choosing between methods, rather than combining methods for maximum advantage.

This excess in behavior is more prevalent in universities than in industry, since the caution inherent in industry, as a result of the fact that profit must accrue from an engineering venture, is not so evident in education.

Yet, there is more at stake on the behavior of education than on the practice of industry, the future of industry.

We have, in education, become enamored with fundamental concepts, and love affairs become subjective in behavior, in contradiction to the espoused purpose of engineering—objectivity. Subjective behavior is prone to excesses and excesses are foreign to engineering analysis.

It *is* necessary that the training of engineers be directed toward the more fundamental general concepts. We know that basic concepts of the physical sciences and engineering sciences have and always will pervade all fields of engineering. Thus narrow training is contradictory to the objectives of sound engineering education.

But in our eagerness to escape totally from the cocoon, let us not lose sight of the fact that we are training engineers, not scientists; that the prime objective of engineering are to provide new and improved designs of systems and processes to satisfy human needs, and to provide analyses of the behavior of systems and processes so that new and better systems and processes may be created; that the engineer cannot treat component factors of behavior separately as does the scientist; that he must combine the effects of behavior of materials, the equilibria phenomena, and the rate processes in order to obtain an economically feasible system.

He must, yes, have an understanding of the fundamental and a facility for *utilization* of the fundamental, but he must superimpose this with a capability for interrelating many coincident occurrences, the effects of which must be combined, by logic and oftentimes still with intuition and empiricism because of the limitations of knowledge. He must crown his achievement of analysis with a system that *works* actually, not only theoretically, and one that is economically feasible.

Thus, we have a dual responsibility in engineering education. We must conve

Recommended by the Graphics Division.

the necessity for conceptual thinking and analysis of fundamental behavior and we must convey the necessity for, and the development of ability for creation of *workable* and *economically feasible* systems and processes.

The turmoil developing is related to the demands of a vociferous group that there be a very rapid transition of the educational process to fulfill the first objective; but one which, unfortunately minimizes, or ignores, the necessity for the second objective and the responsibility for its attainment.

If we achieve only the first objective, we will create men trained only as scientists and only incompletely trained—and if we create scientists only—who will do the engineering?

We must have a thorough training in the physical sciences and mathematics. We must have thorough exposure to concepts and knowledge of equilibrium and dynamics. We must have training in the behavior of materials. And we must have exposure to the combination of fundamentals and logic for the interrelationship of equilibrium, dynamics, behavior of materials, and economics for design. We must have exposure to knowledge of known behavior of systems and their interpretations by, and relationship to, fundamental behavior mechanisms. We must have developed a capability to translate the results to management and the builder of systems via verbal, visual, and graphic methods of communication.

Let us not as a result of the great opportunity provided us by the advancement of knowledge deny its full utilization by restricting its application to the creation of only the first half of the engineer.

Teaching Positions Available

ELECTRICAL ENGINEERING: POSITIONS available for assistant, associate, or professor of electrical engineering. Will require upper-level undergraduate and graduate teaching and part-time research. Expanding graduate program will require applicants to have Ph.D. or equivalent evidence of research potential. Opportunity for summer teaching and research. Write Head, Department of Electrical Engineering, Mississippi State University, State College, Mississippi.

ASSISTANT PROFESSOR AND LABORATORY instructor positions open in the Electrical Engineering Department at Villanova University. Master of Science required for the former, desirable for the latter. Understanding of recent development in Electrical Engineering necessary to teach in the modern curriculum. Apply to Reverend A. J. Mullen, O.S.A., Chairman of Electrical Engineering Department, Villanova University, Villanova, Pennsylvania.

ELECTROMECHANICAL ENERGY Conversion; Applications are invited for a senior position in research and teaching in the general area of electromechanical energy conversion. The initial appointment would be for three years at $15,000.00 per annum. Further information may be obtained from the Professor and Head, Department of Electrical Engineering, University of British Columbia, Vancouver 8, B. C., Canada.

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POSITIONS AVAILABLE FOR teachers of Electrical and Mechanical Engineering, and for teachers of Mathematics. M.S. degree is the minimum requirement; the Ph.D. is desirable. Salary and rank will depend upon qualifications. Excellent fringe benefits. Apply to: Earle M. Morecock, Chairman, Division of Applied Science, Rochester Institute of Technology, Rochester 8, New York.

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APPLIED MATHEMATICS OR MEchanics. Man wanted for teaching in advanced undergraduate and graduate programs. A new Cooperative Ph.D. program is being developed which is sponsored heavily by local industries and a sizable Ford grant. Ph.D. required. Rank and salary will depend on qualifications. Write to R. E. Hundley, Professor of Mechanics, University of Cincinnati, Cincinnati 21, Ohio.

ASSISTANT AND/(OR) ASSOCIATE Professor of Electrical Engineering with interest and experience in one of the following areas: electro-magnetic theory, information theory, digital computer logic and numerical methods, solid state. Ph.D. required. Combination of research, graduate and undergraduate teaching. Address inquiries to Dr. C. Polk, Head, Department of Electrical Engineering, University of Rhode Island, Kingston, Rhode Island.

THERMODYNAMICS, HEAT TRANSfer, and Fluid Flow teaching available at the graduate and undergraduate levels with opportunities for development of curricula and facilities. A unique twelve month position with time for personal improvement possible. Minimum of M.S. in M.E. degree with experience. Contact: Head, Department of Mechanical Engineering, Bradley University, Peoria, Illinois.

Candid Comments

This section is open to comments on articles in the JOURNAL or on engineering education in general. Send comments to the Editor, JOURNAL OF ENGINEERING EDUCATION, University of Illinois, Urbana, Illinois.

Trishkin Caftan

A Russian writer has written a novel titled "Trishkin Caftan," which, translated, means "Trishka's Coat"; and Trishka is a Russian boy's name. The novel's hero is a rapidly growing teenager confronted with the misfortunes of mending his out-grown coat.

A family council was called to decide how to mend the coat. A decision was made to cut off material along the bottom flap of the coat to add to and lengthen the sleeves. When the work was done the boy appeared again before the family council. The council was not satisfied with the results of its first decision because now the coat was too short; and since time had elapsed, the boy had become stockier and the coat was found to be far too narrow. A new decision was made to shorten the sleeves a little bit in order to insert the free material and make the coat wider. When the mending was completed the family council came to the conclusion that the coat is much too short, had too short sleeves and was too narrow, because Trishka had not only grown out of his coat but was also still growing. Therefore, instead of mending the old coat, a new coat of such size should be made so that it could serve until Trishka had matured physically, and still longer. The family felt sorry for time wasted and money spent on mending Trishka's old coat.

I often take part in committee meetings for coordination of studies and programs in order to improve the curriculum of our department. One day it seemed to me that I was a member of the family council discussing the mending of Trishka's coat.

Modern engineering is a rapidly growing body of knowledge and disciplines. Therefore, the problem of under-graduate engineering education is also that of a rapidly growing boy. At least our prominent educators, ASEE, and ECPD, consider it such. Unfortunately they want to use for that growing boy his old coat. Our accreditors recommend to us different ways of mending that old coat. One accreditor thinks that the sleeves are too short. We mend the sleeves cutting some stuff from bottom of lap. The other accreditor finds the coat too short.

I have met here two accreditors and I am sure that the third coming next time will find our educational coat too narrow despite our intentions and best efforts to make it fit our steadily growing boy. Engineering education will never reach maturity because engineering will continue its growth and change. No coat will fit it forever.

I feel that we are at such a stage that the mending of Trishka's coat is no more the proper solution of the problem. Colleges are expected to educate prospective engineers so that they could serve as competent engineers and industrial leaders for the next 15 or even 25 years. If colleges are charged with such a serious responsibility, I assume that it is our duty to declare that our boy has totally grown out of his coat and we can assume our responsibility only when he is provided with an entirely new coat.

Our educational coat is too narrow because, in the present condition, four years are adequate neither to teach nor to learn all that the modern prospective engineer on the bachelor's level should possess. Even if we could design a perfect program under the present conditions, four years would suffice neither to bring our graduates up to the desired level nor to develop their other important attributes. We are short in time and we will remain short unless some changes will be made.

I do not want only to be destructive. Here are my constructive ideas:

1. Expand undergraduate studies to five years;

2. Transfer freshman mathematics, English and a good portion of chemistry,

physics and the humanities to the high school by gradually changing the admission requirements; and

3. Change drastically the present very rigid mass production educational system so that each individual student could bring his speed in studies in balance with his attitude, ability, background, and other individual properties involved in the process of learning and required for successful completion of his studies. Students should be allowed to select themselves the individual time necessary for completion of that engineering program which is considered desirable to achieve the goal. In other words, students should be granted complete academic freedom, and more teaching stimulation must be rendered them by increasing the contact time in our curriculum. This plan will cost more money to both the supporters of institutions as well as students, but a good education is as expensive as any other good thing. Finally, only the rich can afford the luxury of buying bad things.

My purpose is not to outline here the details of developing academic freedom for students and increasing students' contact time with teachers, and their effects on education. Since I was for many years on the staff of a foreign university where this method was used, I can assure that it was successful.

I would favor the combination of ideas 2 and 3, keeping an adequate four-year program in operation. Our primary and high school programs are not over-loaded and I should hope that an additional load would help to combat delinquencies of teenagers.

I hope that my readers will not take me wrong. I completely acknowledge the usefulness of the work being done by our committee in fixing the best possible program for existing conditions, but I am convinced that even the best curriculum will not be able to provide the desired mental maturity of our prospective engineers under the current four-year programs.

J. H. Inveiss
Professor of Mechanical Engineering
Michigan College of Mining and Technology

Engineering for International Service

There are two things wrong with Michigan State's notice "Engineering for International Service" in the January, 1960, issue of the Journal.

These are (1) all Russian engineers do not know the language and not all are at all familiar with the area to which they go, and (2) while it is fine for our engineers to know language and area, the overseas program (a) needs experienced men and not new graduates, and (b) needs men for several areas—not any one in particular.

In this foreign work as it has been with any work of significance or in education, there is no way to prepare a man for a given situation without limiting him since situations change as do individual interests. I believe that an injustice is done to the individual, the educational system and the industries and governments who need educated men when universities train men for a job. Rather universities should educate men who can and will be able to contribute to the whole of society because they have the broadest possible outlook. Thus the horizons of their activity will never be limited and what they do can be as extensive as necessary when challenges arise. In foreign work there is no room for the man with limited or specific horizons.

Paul F. Keim
U. S. Operations Mission to the United Arab Republic, Cairo

Graduate Extension Work

Dr. W. L. Everitt, President
Engineers' Council for Professional Development

Dear Dr. Everitt:

For ten years I have watched the increasing number of engineering colleges that have joined the movement to grant residence credit for the master's degree in engineering for essentially extension work. My file contains material demonstrating the willingness of several respectable institutions to grant up to fifty

per cent of the required credit work for the master's degree out of residence. Some of the literature leaves the impression that all credits may in fact be earned off the campus. When this printed material reaches the hands of industrial employers they have a right to expect similar treatment from the nearest institution, and they move quickly through available channels to achieve this end.

It is my opinion that no educational institution acting alone will be able to deny the industries of its area the recruiting advantage that they will obtain from the announcement that the extension courses they sponsor are acceptable for the master's degree. Nevertheless, such courses more frequently than not are taught by over-time instructors with limited academic qualifications. The students are not in competition with resident students who set class standards to a large degree. The library facilities are limited. Laboratories are usually not available. And an intangible influence, but nevertheless one of great significance, the broad university exchange between students and faculty of many disciplines is wholly absent.

If the Master of Science degree in engineering can be given for such course work, it is evident that the Bachelor of Laws could be offered for work at any court house with an acceptable legal library. Or the M.D. could be earned through any hospital that has modern equipment and good organization. Such educational standards existed in the early part of this century, but standards were established for Law and Medicine that make pressure in this regard useless and therefore nonexistent. Since standards for resident or nonresident study have not been established for the master's degree in engineering, each university must establish such standards for itself under pressures that are related closely to its source of financial support whether it be a private or public institution. The result is an erosion of standards for resident study.

It is not my feeling that there is any need to reduce the amount of engineering extension work for industry. Instead, it should be increased to meet increased demands. Much of the need is for a limited program of scientific improvement, but degree work need not be denied. However, any degree awarded for non-resident study should be clearly designated as such, which will require the establishment of standards after a definition is reached as to what constitutes appropriate work for a degree given in residence. Unless ECPD places the full weight of its influence behind a request that such standards be established promptly, I believe the meaning of the master's degree in engineering will soon be lost by the process of dilution. This happened in the area of the social sciences through misuse of the master's degree in the field of Education. Now graduate educators are trying to reestablish a meaning for the degree Master of Arts, but they are working under a severe handicap.

It seems evident that ASEE is the logical agency to undertake the study of the present status of graduate degrees in engineering as related to nonresident study. However, many institutions represented in ASEE have committed themselves to extensive programs that cannot be classed as wholly resident. Hence, I feel that ECPD aided by EJC may have to take a rather firm hand in seeing that standards are established for the long-term benefit of the profession of engineering as distinct from the short-term pressures of the present critical demand for engineers. Certainly we have a great shortage of physicians in this country, but it would not be a long-term solution to authorize the substitution of extension work for resident medical degrees.

ASEE has in preparation a request to the Ford Foundation that a study of nonresident graduate work be approved and financed. I wish to urge ECPD to add its support to this request by a formal action designating ASEE as the appropriate agency for this study and requesting a report from ASEE on the study and its recommendations. This was the action taken by ECPD which helped in initiating the "Evaluation of Engineering Education" in 1952. As chairman of that study I can assure you that the final report of 1955 was greatly expedited by this action of ECPD. There has been a

lack of agreement in both ASEE and ECPD about the need for accreditation of graduate work. Without reopening that controversy, I believe it is possible to achieve general agreement that the country needs a clear understanding of the standards that should be applied to nonresident work applicable to the master's degree and the percentage of such work that is acceptable for a degree given in residence. Hopefully, we might also receive a recommendation as to the procedures that would be reasonable to control the award of an alternate degree designated as "nonresident." I can assure you that most colleges would welcome some guidance in this difficult matter.

Sincerely yours,

L. E. GRINTER
Dean of the Graduate School
University of Florida

The Art of Teaching

There have been several statements in recent articles in the JOURNAL expressing various amounts of concern over the impression that engineering education is, or resembles, an art. Some people seem to mildly deplore this state of affairs, and urge that engineering education be more "scientific." This argument derives its authority in the text: "Since we are teaching science, we should be more scientific in our teaching." I wish to file this dissenting opinion; that teaching contains the elements of an art, and that the content of the subject does not regulate the manner of its teaching.

A science is an orderly arrangement of knowledge of laws and facts, based on observation. An art is a branch of learning based more on special practice than on general principles, and appealing to the human imagination. My small experience leads me to believe that no Law of Teaching is, or can be, more general than the specific case at hand when a particular teacher faces a particular class. Moreover, I believe that in order to be effective, teaching must appeal to the students' imaginations. Likewise, I am not acquainted with one single unqualified immutable Fact about teaching. I therefore hold teaching to be an art, and I am not the least dismayed over this conclusion.

As for the matter of teaching scientifically because the subject is science, remember that engineering is the *application* of scientific laws and principles, and that design, which is the end result of engineering training, is creative and original; it shows some facets of an art. But to ignore that for a moment, let me draw a few analogies to the "teach science scientifically" phrase. Consider the case of the Music Department—should it not teach musically? And the Drama Department—should it employ more dramatic methods in teaching? If we wish to carry this to the logical end, we may inspire the Economics professors to teach more economically. And—who knows?—perhaps some day the Law College may be asked to teach *legally*.

BEN C. SPARKS
Instructor in Civil Engineering
University of Tennessee

Definition of Engineering

December 28, 1959

To: Professor H. J. Gilkey

This letter is prompted by a reading of and reflections upon your stimulating contribution to the December issue of the JOURNAL OF ENGINEERING EDUCATION. I found your essay helpful in clarifying my own thoughts in this troublesome problem of defining the field of engineering.

Like yourself, I felt the ECPD definition was less than satisfactory, not only for the reasons so well stated in your paper but also because it seemed to me the final phrase, "for the progressive well being of mankind," doesn't belong in a *definition* of engineering. Engineering, in and of itself, does not seem to me to have any inherent bias either for good or for evil. Is it not the use to which they are put which determines whether engineer-

ing works contribute to the progressive well being of mankind or whether they retard such progress?

With the aspiration expressed in the final phrase of the ECPD proposal I am in full sympathy, but the inclusion of this moral observation as an integral part of a definition of engineering seems to me inappropriate. Some people would find it very difficult to rationalize much of the engineering connected with military missile development today as contributing to "the progressive well being of mankind," although they might agree that *it is* engineering and that *it is* necessary for national defense. Thus it seems to me the definition should report briefly, and as accurately as possible, what engineering is—but without including any editorial comment.

Now as to your counter proposal. I like it better than any of its forerunners as a summary statement of the principal characteristics of engineering. And yet as I read and re-read your 27 words and mull over the definition as a whole, I cannot but feel that although they satisfactorily form a kind of formula by which anyone familiar with the field of engineering might recognize it, yet the definition would not be very helpful to some one who was ignorant of the engineering field and trying to find out what it is all about. In short, I think your definition is fine for engineers and others who are familiar with the field of engineering. I doubt its usefulness in helping people who have no previous background in the field to picture in their minds what engineering actually is and what it encompasses.

Frankly, I doubt that it is possible to present an adequate image of engineering in any definition as brief as yours. Consequently I think it would be best to sacrifice the advantage of terseness—admittedly valuable though this is—in the interest of providing a definition that would go farther toward creating a reasonably clear image in the minds of the uninitiated.

As a try in this direction I prepared the enclosed proposal upon which I would welcome your comments. The intent is to include all the essential ingredients in such a way as to enable the lay reader to gain more understanding of what engineering is than he might get from your streamlined definition.

In any event, I congratulate you upon a very helpful analysis of this definitional problem. Your essay appeals to me as being both significant and timely. I hope it will stimulate others as it did me.

PROPOSED DEFINITION OF ENGINEERING AND OF THE ENGINEER

Engineering is a general term covering many branches of technology from the construction of highways to the utilization of atomic energy, through which the materials and forces of nature are developed and controlled for various purposes of mankind. These branches differ among themselves in areas of specialization, size, and historical background, but the following characteristics which are common to all branches identify them as belonging to the field of engineering:

(1) a concern with specific practical results, usually achieved by means of technical projects involving planning, design, execution, and operation;
(2) the application of principles of science, together with judgments based upon knowledge of the state of the art in the branch of technology involved, with due consideration of cost factors, in carrying out these projects;
(3) a capacity for organizing and directing the human skills essential to the accomplishment of complex projects.

Thus the engineer may be described as one whose ability to apply the principles of mathematics and the physical sciences and to direct the work of others in the achievement of engineering projects qualify him to develop ways for the economical utilization of the materials and forces of nature.

W. C. WHITE, *Vice President*
Northeastern University
Boston, Massachusetts

January 13, 1960

To: Dr. William C. White

Your constructive letter and the enclosure of December 28 are appreciated. The point made in the second and third paragraphs of the former appeals to me as thoroughly germane and an important contribution in the interest of objectivity. Essentially the same aspect struck me as I read over the printed article. As a result I have blue-penciled the word *beneficial* (p. 261 line 10 of column 2). Evidently we are in agreement that as a part of the proposed definition, such a term is out of place.

The initial comments in paragraphs four and five are accepted as true and valid. Might not the "out" to this aspect be an attempt to meet the needs of the two constituencies (the insider—the engineer, and the outsider—the non engineer or layman) separately? In other words let us strive to evolve the shortest, tersest definition possible from the standpoint of technical validity and adequacy —one that to the critical, legal-type mind "holds water." Let this be followed by an amplified version designed to present a sketchy word picture of engineering in terms meaningful to the layman. Unquestionably this is about what the ECPD Committee had in mind as they presented their purported definition and followed it up with the little essay (having in my estimation, done a rather poor job of each). This would mean starting out with my terse definition (or a better one) and following it with the essence of your enclosure. The result might shape up somewhat as follows:

A PROPOSED DEFINITION OF ENGINEERING AND OF ENGINEER

"Engineering is the application of science and art to the economic utilization of materials and forces in conjunction with the organization and direction of essential human skills."

Amplifying Comment

Engineering is a general term covering many branches of technology (ranging from the construction of highways to the production and utilization of atomic energy), incidental to which materials and forces are processed and controlled. Clearly the projects which lie within the scopes of these several branches differ widely with regard to their nature and area of specialization, and in magnitude, but the following characteristics (common to all branches) identify them as belonging to the field of engineering:

1. A concern with specific practical results which embody one or more of the following attributes: planning, designing, execution, operation, maintenance and rehabilitation, to which might be added (especially as applied to military engineering) purposeful demolition.
2. The application of principles of science together with judgments, based upon knowledge of the state of the art in the branch of technology involved, and with due consideration of cost factors in carrying out these projects.
3. The organization and direction of the human skills essential to the culmination of such projects.

It follows that an *engineer* may be defined as: A person duly qualified to practice engineering in one or more of its branches (as engineering has been herein defined and delineated).

Comment

In most states authorization to assume the title *engineer, professional engineer, registered engineer* or *registered professional engineer,* embodies formal registration superimposed upon the necessary preparation and other essential technical qualifications. The term *professional engineer* is a redundancy (since engineering is itself a profession) but can be justified on the basis of the widespread use or misuse of the term *engineer* in the trades as a synonym for an engineman or a mechanic.

Closing Remarks

You will recognize the proposed Amplifying Comment as essentially your definition. The slight omissions or altera-

tions are for the most part mere whims—an indefinable (and possibly indefensible) preference for one word or combination over another. In a case or two my reason for the indicated change is a bit more tangible, as for example: deletion of "of nature" and "of mankind" (per discussion under my ASEE No. 1 on page 257). "Historical background" looks good and reads well but I find myself unable to pin it down as having specific applicability or pertinence. Perhaps on this I'm just a bit thick and need to be set right with respect to something that you see and I don't.

With these quibbles aside, I wonder if my idea of a terse definition followed by your type of amplification may not constitute a workable answer to the objection raised in your paragraphs four and five?

Again let me express appreciation of your constructive comments. They have advanced my own thinking several notches beyond where I had gotten previously.

H. J. GILKEY

January 20, 1960

To: Professor H. J. Gilkey

Upon my return from a meeting of the Committee on the Development of Engineering Faculties held last week in Chicago I found your good letter of January 13 waiting for me at Northeastern. It is good of you to give so much time to a discussion of my alternate proposal regarding the definition of engineering.

Your idea of adopting the terse definition for those of us who are in the field and using the revised and amplified statement as one for prospective students of engineering and for the body politic appeals to me as being sound and sensible. I am entirely in accord with all of the revisions you have made in my proposal and am pleased to find that some of my ideas struck you as being useful.

Here's hoping we can find some kindred souls, unhappy with previous efforts at defining the field of engineering and the engineer, who will take kindly to our suggestions.

W. C. WHITE

Small Rocket

I have noted the article, "A Small Rocket for Laboratory Demonstration" by Mr. A. R. Deschere which appeared in the December 1959 issue of the JOURNAL OF ENGINEERING EDUCATION, with interest since we have been in the process of constructing this engine in the Department of Ordnance at the United States Military Academy for the past year. Having recently completed a few outdoor preliminary runs we have gained the following experience to date which may be of some interest to others experimenting with this device.

1. We have successfully started this engine reliably using spark ignition by igniting at minimum air rates to support combustion. This method eliminates the initial exhaust of unburned gasoline vapor and greatly enhances the safety factor for operation in the laboratory. The spark plug is a standard automotive type (Champion N-16Y or equivalent) with gap opened to ¼" and activated by a 110 V. AC primary to standard furnace oil burner ignition coil.

2. We have eliminated the pressurization of the fuel tank by air supply and substituted nitrogen at 60 psi which is readily available in our facility and further enhances the safety aspects of laboratory operations.

The project at present is nearing completion for tests of nozzle variations proposed by cadets taking the Armament Engineering subcourse of the Ordnance Engineering series at West Point. We should be happy to furnish details of our final runs to any interested persons, as a portion of our comments to Mr. Deschere.

JOHN D. BILLINGSLEY
Colonel, USA
Professor and Head
Department of Ordnance
United States Military Academy
West Point, New York

Aero Division Bulletin

Aeronautical Division Holds Joint Meeting with I.A.S.

The Aeronautical Division of the ASEE and the Institute of the Aeronautical Sciences acted as co-sponsors of an Aerospace Education Session at the Annual Meeting of the I.A.S. at the Hotel Astor, New York City on January 25, 1960. The meeting was in the form of a panel discussion of the topic, "The Influence of Computing Machines Upon Aerospace Engineering Education." The chairman for the session was Robert M. Rivello, Associate Professor of Aeronautical Engineering at the University of Maryland. The members of the panel, their affiliation, and the subject which they discussed were as follows:

"Computer Applications in the Aerospace Industries," J. Friedrich Vandrey, Director, Aerospace Physics Dept., Space Flight Division, Martin Company.

"Computing Machines at the Langley Research Center," Thomas B. Andrews, Chairman, Computing Group, Langley Research Center, NASA.

"Educational Influence of Computers as Seen by the Computer Industry," James A. Kearns, Univ. and Research Inst. Rep., Eastern Region, Data Processing Div., IBM.

"The Impact of Digital Computers in Engineering Education," Thomas J. Herrick, Assoc. Professor, School of Aero. Engineering, Purdue University.

"The Role of Computers in Aeronautical Education," Theodore H. H. Pian, Assoc. Professor of Aeronautics and Astronautics, Dept. of Aeronautics and Astronautics, MIT.

Dr. Vandrey and Mr. Andrews discussed typical applications of computers and the role of the engineer in the formulation and programming of such problems in industry and research. They also presented recommendations on how present and anticipated future industrial uses of computers could be taken into account in the engineering and mathematical training of engineering students.

Dr. Kearns described the types of computer training and equipment currently available in many universities. He also reviewed the ways in which the computer manufacturers have aided the universities in the acquisition of computers by making their equipment available at reduced prices and the support that has been given to the universities through grants from the National Science Foundation and the Ford Foundation.

Professor Herrick and Dr. Pian discussed the experience of Purdue and MIT in their undergraduate and graduate programs in aero- and astronautics in which course contents have been revised to meet the impact of the automatic computing machines. Both found student interest high and a major portion of machine time at both institutions is on student problems and instruction.

Following the presentations by the panel members there was a spirited discussion with questions and statements of opinion from the audience. The concensus of this discussion was that though the computer training is important, it must supplement the present approach and it should not be given at the sacrifice of adequate training in fundamental physical principles. There was some fear expressed that machines are becoming a crutch to some engineers and that they are being used for many problems where their use is unwarranted. The objective of the engineering educator should be to modify courses and curricula to take cognizance of the changes in industry which have been brought about by computers but not to train the student engineer to be a machine programmer.

What's Going On in ASEE

W. LEIGHTON COLLINS, *Secretary* ASEE

The Executive Board was unable to meet with a Section in April, despite two firm invitations to do so. Most of the meeting was devoted to current and proposed special programs, and this accounting of the meeting is devoted almost entirely to those items.

Secretary Collins reported that individual members now total 9,440, a new record. Next year's goal will have to be 10,000! Industrial members total 183, also a new record. The election to active institutional membership of Antioch College and San Jose State College was voted a matter of record.

The committee appointed to study the transfer of membership records to a punch card system is functioning. The printing of the Yearbook-Directory is closely related, as well as the question of whether ASEE should maintain data on all engineering teachers.

The JOURNAL size has been standardized by the budget. Actions on papers submitted is governed accordingly; a decision will be made on nearly every paper by the end of the fiscal year. Permission was granted University Microfilms, Inc. to furnish enlarged copies of unavailable issues of the JOURNAL from the microfilm copies they regularly produce. ASM has been given permission to reproduce single copies of individual articles at cost, in accordance with their recently established reproduction policy.

The advertising in the JOURNAL has been maintained throughout the year at a rate about 20% above that of last year. But even so, advertising pays for only about 60% of the "cost of printing" the JOURNAL.

The third-quarter financial report indicated a sound operation for the year. Both income and expenses are in general accord with the budget. The increase in advertising, the recovery of indirect costs, and interest from short-time investments make the income picture look good.

On the recommendation of ECRC a proposal for the establishment of a coordinating council consisting of all organizations interested in research administration was approved. The general plan is for ASEE, the Association of Land Grant Colleges and Universities, and the University Business Officers Association to provide open forums, and the American Council on Education to be the "umbrella" organization.

The establishment of a group life insurance plan for members of ASEE was not approved. The reasons are that so many members already have opportunities to participate in other society or institutional programs, that there have been no requests from members, and that the cost did not appear to be particularly attractive. The President, Treasurer, and Secretary were instructed to study the pending Simpson-Keogh Legislation enabling those who are self-employed to make annual contributions to build up retirement income to supplement Social Security, the contributions being deductions for personal federal income tax purposes.

The proposal for the "Evaluation of Technical Institute Education" was approved, including the authorization to seek funds. The request of the Technical Institute Division for permission to seek funds for the preparation of a movie to supplement "The Engineering Technician" was tabled. It did not seem appropriate to seek two grants in the same general area at the same time. The organization of the Technical Institute Division was discussed at some length, and a sympathetic attitude was expressed toward the current proposal of a dual functioning in the Division, one aspect based on representation of institutions having ECPD accredited curricula and the other

on an academic forum of technical institute teachers.

The general plans regarding the Engineering Design Conference to be held at Case Institute of Technology were approved. It also was voted to approve the request of the Mechanical Engineering Division to sponsor an International Conference on Mechanical Engineering Design Education in the summer of 1961. It was voted that ASEE should be alert to the sponsorship of studies of mechanical engineering laboratory instruction and of the nature and propreties of materials and to actively participate in them in appropriate ways.

The resolution on bi-lateral engineering education missions between the member nations of UPADI submitted by the International Relations Committee was approved. The proposal for an educational mission to Latin America was not approved because it was believed that an invitation should be received first, and that no plan should be proposed until it was reasonably certain that member institutions of the Society would be interested in implementing the findings. At the same time the Executive Board expressed its recognition of the importance of cooperation on international problems in engineering education and recorded it's desire to encourage such programs in every way possible consistent with the resources of the Society. The proposed study to promote employment of foreign students in industry was referred to RWI for a recommendation and expression of opinion as to whether it really was an ASEE problem. The International Relations Committee was requested to draft a proposal to submit to NSF for ASEE to function as a clearing house for foreign teaching assignments. The request of the International Relations Committee to sponsor a General Session on International Engineering Education was approved.

The suggestion that a short study of new equipment needs of colleges of engineering be made for the National Science Foundation was approved. The purpose is to determine the magnitude of the problem in order that NSF can decide on its interest in so far as future programs are concerned. ECAC is to make the study.

The proposal from the University of Wisconsin for ASEE sponsorship of a two-week summer short course on "Transport Phenomena" (Rate Processes) for the summer of 1961 was approved.

The Nuclear Committee was authorized to proceed with its plans for developing a summer institute program on nuclear energy for 1961. The contract for the study of Effective Criteria for Graduate Work in Nuclear Energy is being drafted by the Atomic Energy Commission and should be received shortly.

Vice President-Elect Hall explained the proposed program on engineering administration being planned by Purdue University for the summers of 1961 and 1962. The Executive Board voted to cooperate in whatever way seemed to be most appropriate.

The work of the Committee on Development of Engineering Faculties and its future were discussed at great length. It was agreed ways and means be found to continue the desirable aspects of the work started, and that President Teare prepare a statement of the comments and proposals so they can be discussed with CDEF and President-Elect Walker for the development of future plans.

The continuing education of engineers was discussed, with the conclusion being reached that colleges were doing well in developing programs and meeting needs. The fact that many engineers did not wish to keep abreast of current developments is lamentable, but that is an individual problem.

The proposed study of units in nuclear science and engineering was again discussed. That portion of the proposal pertaining to nuclear energy was referred to the Nuclear Committee, with a request for a decision on what seems to be a worthwhile proposal and a statement of reasons for the decision made. The part of the program involving the complete change from English to metric units appeared to require a much broader attack than contained in the proposed joint ASEE–ANS study.

Permission was granted Secretary Collins to absent himself from the Society

headquarters to accept a State Department invitation to spend a month in Paraguay and one week in Argentina as a consultant in engineering education, provided Assistant Secretary Seyler can be in the office for one month and provided there is no cost to the Society. The services would be rendered while in South Amreica to represent ASEE at the Pan-American Congress on Engineering Education on an NSF grant.

"Engineering in World Affairs" was approved as the theme for the 1961 Annual Meeting at the University of Kentucky. The dates of June 18–22 for the 1962 Annual Meeting at the Air Force Academy were approved. It also was voted that the Electrical Engineering Division be responsible for the coordination of programs with the American Institute of Electrical Engineers for appropriate joint annual meeting programs in 1962; AIEE meets in Denver at the same time ASEE meets at the Air Force Academy. The establishment of an Annual Meeting Reserve Fund was approved. It is to be made up of the unexpended balances returned to the Society by local committees, starting with the 1960 Annual Meeting.

It was agreed that K. L. Holderman be requested to record suggestions for the modification of the National Defense Education Act of 1959 and that they then be referred to the National Legislation Committee for a recommendation of appropriate Society action.

The appointment of a Commmittee on Instrumentation, D. P. Eckman, Chairman, was announced.

The election of the following officers for 1960–61 was made a matter of record.

Number of ballots cast 533

For President—E. A. Walker 531
For Vice President, West of Mississippi River—M. R. Lohmann 504
For Vice President, Curricula Divisions—N. A. Hall 521
For Treasurer—W. W. Burton .. 528

W. Leighton Collins was appointed Secretary, Jimmy W. Seyler, Assistant Secretary, and Paul T. Bryant, Editor for 1960–61.

A NEW TEACHER EDUCATION PROGRAM

A teacher-education program with real "meat" in it is being initiated by the University of Chicago. A new graduate department of education is to be opened in September and has as its objective producing teachers who know their specialties, scholars who know how to teach. It will take two years to earn an M.A. in the teaching of a chosen specialty. The first year is devoted to graduate work in the chosen subject under the supervision of the top scholars of the University; but there is a weekly seminar in the psychology of learning and the philosophy of education, as well as observation of high school teachers. In the second year there is a teaching residency in a selected high school for which the student will earn three-fifths of a teacher's salary. Once a week he will meet with a university scholar to go over the problems in teaching his subject. To receive the M.A. degree the major department, the education department, and the supervisors of his teaching must certify to competence.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 22–23, 1960	H. D. Sims, Bucknell University
Illinois-Indiana	Rose Polytechnic Inst.	May 14, 1960	E. A. MacLean, Rose Polytechnic Inst.
Kansas-Nebraska	Univ. of Wichita	Oct., 1960	H. L. Kipp, Univ. of Kansas
Michigan	Univ. of Michigan	April 23, 1960	R. Schneidewind, Univ. of Michigan
Middle Atlantic	E. I. Du Pont de Nemours, Wilmington, Del.	May 14, 1960	J. I. Clower, Univ. of Delaware
Missouri-Arkansas	Univ. of Missouri	April 23, 1960	Jos. C. Hogan, University of Missouri
National Capital Area		Oct., 1960	M. A. Mason, George Washington Univ.
New England	Wentworth Inst. Boston, Mass.	Oct. 15, 1960	E. F. Littleton, Tufts Univ.
North Midwest	Marquette Univ.	Oct., 1960	R. J. Kipp, Marquette Univ.
Ohio	Fenn College Cleveland, Ohio	April 29–30, 1960	N. R. Rimboi, Fenn College
Pacific Northwest	Univ. of Idaho	May 13–14, 1960	Paul Mann, Univ. of Idaho
Pacific Southwest	Stanford University	Dec. 27–28, 1960	Homer H. Grant, Univ. of Southern California
Southern meeting	Harvey Mudd College, Claremont, Calif.	April 23, 1960	
Northern meeting	San Jose State College, San Jose, Calif.	May 14, 1960	
Rocky Mountain	USAF Academy	Apr. 29–30, 1960	Archie Higdon, U. S. Air Force Academy
Southeastern	Univ. of South Carolina	April 21–22, 1960	Jesse Coates, La. State Univ.
Southwest	Lamar State College, Beaumont, Tex.	Apr. 29–30, 1960	Frank Bromilow, New Mexico State Univ.
Upper N. Y.-Ontario	Univ. of Buffalo	Oct., 1960	C. M. Fogel, Univ. of Buffalo

Mid-Winter Meetings–1961

Cooperative Education — Jan. — University of Detroit
Information: D. C. Hunt, Director of Coordination and Placement, University of Detroit, Detroit, Mich.

Engineering Graphics — Jan. 19–21 — University of Wichita
Information: A. C. Risser, Head, Engineering Drawing, University of Wichita, Wichita, Kansas

College-Industry Conference — Feb. 2–3 — University of Cincinnati
Information: C. Wandmacher, Assoc. Dean of Engineering, University of Cincinnati, Cincinnati, Ohio

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